

NATIONAL GEOGRAPHIC CHANNEL'S MOST AMAZING DISCOVERIES, SEPT. 6-10 AT 9 P.M. ET/PT

NATIONALGEOGRAPHIC.COM/MAGAZINE

SEPTEMBER 2004

NATIONAL GEOGRAPHIC

GLOBAL WARNING

BULLETINS FROM A WARMER WORLD

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THE COVER

With Alaska's climate heating up, wildfires are on the rise.

BY PETER ESSICK

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ON THE WEBSITE

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STORYTELLING Listen to traditional American Indian stories.

VIDEO See the small but ferocious honey badger in action.

INTERACTIVE ART Explore a shipwreck on the ocean floor.

FORUM Voice your opinion about global warming.

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OnScreen & Online

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SEPT. 6-10, 9 P.M. ET/PT

Amazing Discoveries

Share in NGC's *Most Amazing Discoveries*: as when our cameras uncover ancient Chinese tombs. Or when our filmmakers catch the moment the *Titanic* is found in the Atlantic depths. And follow Zahi Hawass as he opens a 4,500-year-old sarcophagus (left) in the Great Pyramid at Giza, all during a week of thrilling discovery.

TUESDAYS, 10 P.M., BEGINNING SEPT. 14

Seconds From Disaster

What went wrong when a wing on the supersonic Concorde burst into flame during takeoff, killing all 109 persons on board? What chain of events caused the nightmarish explosion of the Chernobyl nuclear reactor? How and why did a ferry capsize in shark-filled waters off Sumatra? Exploring the science of catastrophe, a new series ticks off the seconds to disaster.



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TUESDAYS, 8 P.M.
BEGINNING SEPT. 14

Expeditions to the Edge

Examine the critical choices made when expeditions are threatened by harrowing events, including an avalanche and a volcanic eruption.

Channel and NGT&F programming information accurate at press time; consult local listings or the Society's website at nationalgeographic.com

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SEE THE EFFECTS OF GLOBAL WARMING View animations showing the pressure of climate change on Arctic sea ice. ■ **TAKE AN INTERACTIVE QUIZ** Test your knowledge on global change and score yourself against your peers. nationalgeographic.com/magazine/0409

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Flashback to the past with our collector's edition; watch an interview with archivist Bill Bonner; learn how to make tintype prints; and e-greet a friend with a vintage postcard at nationalgeographic.com/magazine/bestvintage

Behind the Scenes

MEDAL OF FREEDOM

With Honors

When Gilbert M. Grosvenor was in college, he dismissed the only geography course he took as "boring." That was more than half a century ago. This summer his service to geography, and to the National Geographic Society, earned him



the Presidential Medal of Freedom (left). In a June 23 ceremony at the White House, George W. Bush awarded the National Geographic's Chairman of the Board with the country's highest civilian honor—second only to the Medal of Honor given by Congress for military valor. "We honor him today for his good stewardship of a great

American institution," said the President (above right, with Grosvenor).

Gil's grandfather Gilbert H. Grosvenor was the magazine's first full-time Editor; his father, Melville Bell Grosvenor, was its third. In 1970 Gil took the reins after a decade and a half spent working on the magazine. As Editor, he set NATIONAL GEOGRAPHIC on a new path. It had always entertained and educated its readers; now it challenged them as well. Under Gil the magazine turned a spotlight on the environment and on places in turmoil. At the time, conservative voices at the Society objected to these changes, but the readers didn't, and circulation surged.

In 1979 Gil (right, at center) accompanied Canadian diver-physician Joe MacInnis, at left, and underwater photographer Al Giddings on an expedition to the North Pole. The next year, Gil became President of the National Geographic Society and, later, Chairman of the Board. When studies showed Americans lacked basic geographic knowledge, Gil found a new mission. Declaring himself "angry . . . embarrassed . . . determined," he devoted himself to making the Society a force for change, establishing the National Geographic Education Foundation and the National Geographic Bee, among other programs.

For 50 years, says Bill Allen, the magazine's current Editor, Gil has "led us and inspired us in so many roles: writer, photographer, editor, business leader, innovator—and always, teacher." If Gil Grosvenor has his way, no student will ever find geography "boring" again.



NATIONAL GEOGRAPHIC TRAVELER

A Grand Tour for the 21st Century

When *Traveler* magazine asked readers to name their ultimate travel fantasy, nearly half said they yearned for a trip around the world. So *Traveler* queried savvy globe-trotters to compile a list of the top 80 places any well-rounded person should aspire to visit. The result: an updated version of the grand tour, a journey taken by 18th-century British aristocrats to complete their education. While the old tour featured standbys such as Paris, Rome, and Venice, the new grand tour favors unexpected meccas, including (clockwise from top left) Luang Prabang, Laos; Riga, Latvia; Tasmania, Australia; and Miami, Florida. "People think traveling the globe is just this dream," says *Traveler* Editor Keith Bellows. "But whether you do it in increments or in one fell swoop, it's totally possible." The issue, full of blueprints for making the dream a reality, is on newsstands October 1.



MICHAEL YAMASHITA



ALEXANDRA AVAKIAN



CATHERINE KARNOW



KRIS LEBOUTILLIER

THE DIGITAL WORLD

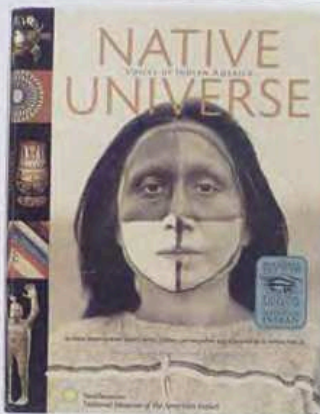
Photo Workshop

Struggling to make the transition from film to digital photography? National Geographic photographers are taking their show—and skills—to the open highway in a custom-designed, 18-wheeler photography studio. For six weekends this fall, shooters who've gone digital in the pages of NATIONAL GEOGRAPHIC will offer free advice on how to take better digital pictures and print pictures at home. The truck will be parked in Circuit City lots in Greensboro, N.C.; Landover, Md.; Richmond, Va.; and several other cities beginning September 24. Watch for details in our magazines and your local newspapers.



NATIONAL GEOGRAPHIC

CELEBRATE PHOTOGRAPHY TOUR 2004



INDIAN RENAISSANCE (PAGE 76)

Get More To learn more about a subject in this issue, try these NGS products, log on to nationalgeographic.com, or call 1-888-225-5647.

- **Indian Country Supplement Map** To order a larger format version of this month's map, go to nationalgeographic.com/maps.
- **Native Universe: Voices of Indian America** book. Get eyewitness accounts of American Indian history and contemporary life. Includes photos of artifacts from the Smithsonian's National Museum of the American Indian (\$40).
- **Books and Islands in Ojibwe Country** book. Journey with novelist Louise Erdrich as she explores her Ojibwe heritage (\$20).

NGS Calendar

September

"Lives in Transition: Expressions of Refugee Youth" exhibit continues through the end of September at the United Nations, NYC.

14 National Geographic Channel Fall Season Premieres. *Expeditions to the Edge*, 8 p.m. ET/PT; *Interpol Investigates*, 9 p.m. ET/PT; *Seconds From Disaster*, 10 p.m. ET/PT

23 Carol Beckwith and Angela Fisher lecture on their book *Faces of Africa* at the Field Museum, Chicago.

October

6 "Passages: Photographs by Carol Beckwith and Angela Fisher" exhibit opening. See images, masks, and body adornments from African rites of passage at National Geographic, Washington, D.C.

8 Anna Quindlen lectures on her book *Imagined London* (National Geographic Books) at National Geographic, Washington, D.C.

14 National Geographic Atlas of the World, 8th Edition available in bookstores

22-24 All Roads Film Festival. Indigenous and minority culture filmmakers tell their stories at the Egyptian Theatre, Los Angeles.

28 "Mapping With Paper and Pixel" exhibit opening. Explore the richness of modern mapping at National Geographic, Washington, D.C.

28-30 All Roads Film Festival, National Geographic, Washington, D.C.

Calendar dates accurate at press time; go to nationalgeographic.com or call 1-800-NGS-LINE (647-5463) for more information

Visions of Earth

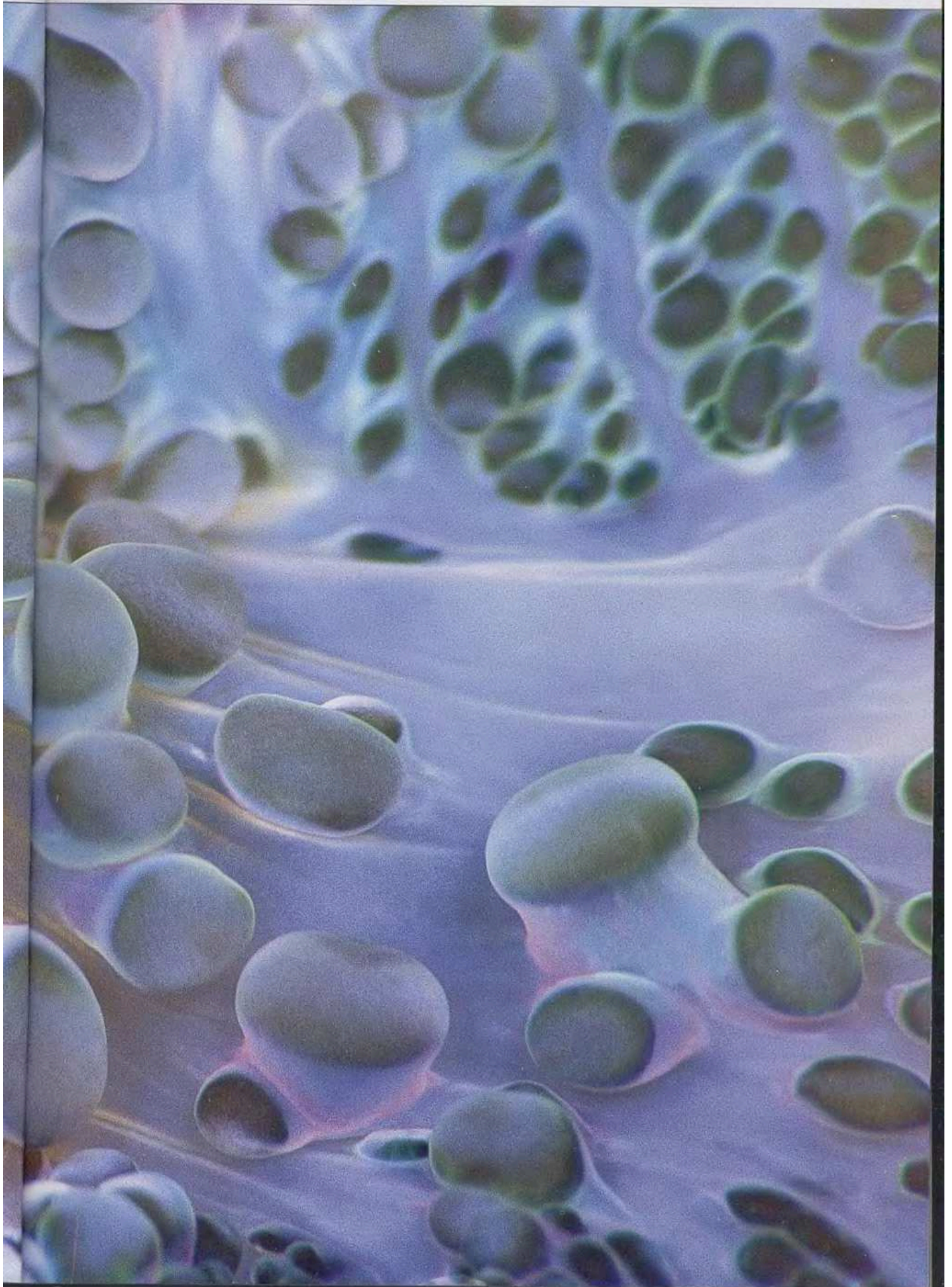
OFF THE SOLOMON ISLANDS

In my abstract images I often try to evoke the otherworldliness of a faraway planet. After all, life on Earth, whether it's in the oceans or on land, evolved from the same materials that the stars are made of. I took this shot in one of the most biodiverse marine environments on our planet—the western Pacific. These corallimorpharians, creatures related to hard corals, are fairly nondescript when you see them from a distance underwater. But by magnifying them with a macro lens and lighting them with strobes, their color and form become sublime. —Chris Newbert

MINDEN PICTURES

► E-greet a friend with this image from the ocean at nationalgeographic.com/magazine/0409.





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From the Editor



PETER ESIK

After a decade as Editor in Chief, I have a pretty good idea which articles will provoke a lot of angry letters. Whenever we publish stories that challenge widely held beliefs, some readers get mad, and they write to let us know.

Well, we're about to do it again. We're devoting 74 pages of this issue to a three-part series of stories on global climate change, and I'd be willing to bet that we'll get letters from readers who don't believe global climate change is real, and that humans contribute to the problem. Some readers will even terminate their memberships.

Why would I publish articles that make people angry enough to stop subscribing? That's easy. These three stories cover subjects that are too important to ignore. From Antarctica (above) to Alaska to Bangladesh, a global warming trend is altering habitats, with devastating ecological and economic effects.

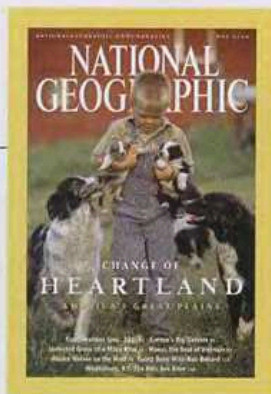
So I'm asking you—even those of you who don't believe the Earth is getting warmer and that human behavior is a contributing factor—to turn to page 2. This isn't science fiction or a Hollywood movie. We're not going to show you waves swamping the Statue of Liberty. But we are going to take you all over the world to show you the hard truth as scientists see it. I can live with some canceled memberships. I'd have a harder time looking at myself in the mirror if I didn't bring you the biggest story in geography today.

Bill Allen

Forum

May 2004

"Dance of Death"—a photo essay on the killing of a moose by a pack of wolves—sparked a heated debate (see the following page as well as our online forum at nationalgeographic.com/magazine/0405/feature6). Should park rangers have stepped in to save the moose? Nearly two-thirds of the people who responded to our online poll on the subject believe that humans shouldn't interfere with nature in such cases.



The Late Great Plains

"Change of Heartland" is a story that needed to be told. The author, John Mitchell, truly captured what life is like on the ever vanishing farms of the Plains. Generations of strong, resilient families shaped this country into a great nation. The government needs to help these people with whatever aid is necessary to keep alive their way of life.

MICHAEL M. DONOVAN
Centennial, Colorado

I grew up in the Great Plains. I was appalled by your article. The gloom-and-doom aura permeating the story is definitely not the theme of our life here, nor is it the outlook for the area. We appreciate the coverage, but the picture presented of this beautiful land is distorted.

MARVIN S. SPRACKLEN
Chadron, Nebraska

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The magazine's website: nationalgeographic.com/magazine

For an online index of all National Geographic publications, go to: nationalgeographic.com/publications

Thank you for calling attention to an issue that has quietly become a crisis—the rapid depopulation of America's Great Plains. Nearly half of the counties in Oklahoma, which I represent in the U.S. Congress, are losing their population at an unsustainable rate. Today most of the towns in western Oklahoma have a hundred years ago, and as this trend worsens, it strains public services like schools, hospitals, and police and fire departments to the breaking point. You are right to point out that it will take more than an act of Congress to remedy this situation. But your article neglects another equally important fact: This depopulation is not merely a natural, inevitable trend, but the result of decades of political negligence. Government policy, quite simply, has failed these people.

REP. BRAD CARSON
*U.S. Congress
Washington, D.C.*

Your article was typical of the thinking of those who don't live on the Great Plains. You extol the idea of changing the prairie back to what it was before the evil Europeans arrived with their plows and cattle. One wonders if



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Dance of Death

I am outraged by the decision to allow the meaningless suffering of a moose. I know there's supposed to be some grandiose purpose in not interfering with nature, but this is different. Can't you see that? Simply shoot the moose and nothing changes. They all eat it, just as nature had intended.

PIERCE BLOOM
Birmingham, Alabama

"Dance of Death" reveals the brutal reality of a natural death in the animal kingdom. I have no doubt that these photos will shock many readers who have delusional "Disneyfied" notions of life and death in the natural world. The park rangers are to be



YVA MOMATIUK AND JOHN EASTCOTT

commended for not interfering with a natural cycle that predates human civilization.

MICHAEL P. EGAN
Port Washington, Wisconsin

The decent thing to do would have been to put the moose out of its misery. The photographers are wildlife paparazzi, racing from place to place in their quest for the ultimate snuff picture.

SHELLEY SKREPNEK
Whitelaw, Alberta

Momatiuk and Eastcott's anthropomorphic attempt to soften the death of the moose for readers by injecting a measure of spiritual "acceptance" and "ceremonial exchange . . . the flesh of the hunted in exchange for respect for its spirit" falls short of your standard of journalism. It detracts from an otherwise excellent and unique photo essay. That moose wasn't "accepting" anything. It was simply too hurt and weak to continue fighting and probably sensed that it was in bad trouble. We can't read the innermost thoughts of the wolves, but they were likely more focused on a full belly than respecting the spirit of the moose.

MIKE DOXEY
Fairbanks, Alaska

some people have ever considered where the grain for their bread or steaks for their grills would come from—and how much these foods would cost—if such ideas ever came to pass.

LARRY ELLIOTT
Billings, Montana

I grew up on a farm in west-central Missouri. I never wanted to stay on the farm, but after college I realized I never really had a choice in the matter, due to the economic reality of farming. One day in the mid-1990s my

father and I attended a county soils and crops meeting. There were probably over 200 farmers there. Fewer than 20 were under age 40, and of those only three, including myself, were under 30. I have often wondered what America's agricultural community will look like in 20 or 30 years when these older farmers pass on. I fear that most of our family-owned land will be sold and consolidated on an unprecedented scale, mostly to entities ending in "Inc."

BRANDON WALKER
Columbia, Missouri

FROM OUR ONLINE FORUM
nationalgeographic.com/magazine/0405

You state that our bank may be shuffling foreclosures and that we've just dried up and blown away. Portraying us in this way does a great disservice to our

customers, our friends and neighbors, and ultimately to those of your readers who might actually believe what you print. We're still proud and comfortable that we're in the middle of America. But we're also tired of the media coming to us, taking pictures and getting quotes, and then making light of who we are and where we live. If you can't say something nice about us, just leave us alone.

MURRAY D. LULL
President

*The Smith County State Bank
and Trust Company
Smith Center, Kansas*

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Cuba, Kansas

Congratulations to photojournalist Jim Richardson on his three-decade pursuit that has made my hometown much more fascinating than I remembered.

The days and events seemed anything but exotic—hardly intriguing enough for the pages of NATIONAL GEOGRAPHIC. But through Richardson's vantage point comes a study of life in a small town with simplistic beauty and innocence. Any town would be lucky to have Jim Richardson as historian and publicist. Thank you for being there, Jim.

MARGO KELLER POSNANSKI
Kansas City, Missouri

Europe's Big Gamble

I look forward to a time when each fragmentary piece of Europe can take pride in its heritage as part of a strong federation. I hope that by uniting we can have more room to celebrate our differences.

MICHAEL BALL
Ticehurst, East Sussex
FROM OUR ONLINE FORUM
nationalgeographic.com/magazine/0405

I object to the perpetual presentation of the decreasing European population as a problem. I think our world is stressed by the pressure of the ever growing human population. Europe is not creating a problem; Europe's low birthrate is contributing to the solution.

ROHALT GYSEMANS
Heist op den Berg, Belgium

Sadly, not many Americans are concerned with recent events in Europe. With ten countries joining the European Union, possibly making Europe's economy rival ours, the general public should be knowledgeable on this subject. Otherwise we will become what the rest of the world thinks of us: ignorant.

LOUIS C. HASELY
Durango, Colorado

Why was the effort to enlarge the European Union called a

Generations of strong, resilient Plains families shaped this country into a great nation. The government needs to help these people with whatever aid is necessary to keep alive their way of life.

"Big Gamble"? Why were the majority of photographs dedicated to protests, poverty, and problems that the EU targets to change? In Europe sincere foes have become real friends. France and Germany, formerly troubled neighbors, became the engine for the new EU. Europe has torn down iron curtains. A more open-minded title would have been "Europe's Big Opportunity."

DIETRICH REIN
Neustadt Weinstrasse, Germany

Being Bob Ballard

Cost of Bob Ballard's expedition per day: \$40,000. Cost of ROV's manipulator arm: \$150,000. Learning that all those Ph.D.'s didn't think to bring a spare hydraulic pump: priceless!

TERRY HUCKABY
Tennessee Colony, Texas

Geographica: Foreign Service

Why do we have thousands of troops scattered all over the world? Is the United States in

the world domination business now? Why do we have troops in Japan, Italy, Germany, Australia, Singapore, the U.K., and the tiny island of Diego Garcia? What are we protecting them from? We, as taxpayers, are paying for troops to be in countries where we are not wanted—countries in no need of protection. Our politicians need to look for ways to close these bases and bring troops home.

SUSAN TATREAU
Placentia, California

Hanoi

Your article states, "Not until 1975 . . . did Vietnam and Hanoi see the end of war and foreign subjugation." I, and other veterans I knew, did not go to South Vietnam to help subjugate South Vietnamese people. We went there to try to help protect them from being oppressed by North Vietnam.

KEN ROUGHT
Williamstown, New Jersey

ZipUSA: 41858

With much trepidation I opened my newly arrived NATIONAL GEOGRAPHIC straight to the article on Whitesburg, Kentucky. I was born and grew up 17 miles from there. I assumed it would be yet another negative portrayal of all things Kentucky. (I have no objection to being referred to as a hillbilly; it is the implication of ignorance, stupidity, and lack of education that gets attached to that label that I abhor.) Instead, I was delighted to find an insightful and upbeat article.

TAMRA SORRELS
Wise, Virginia

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SHIFTING LEARNING INTO HIGH GEAR.

High school auto repair shops get an upgrade, while students gain real-world skills



Students at Philadelphia's Swenson Arts and Technology and West Philadelphia high schools will graduate with more than a diploma. They'll leave with a carload of experience and skills in everything from overhauling transmissions to analyzing anti-lock brake computer systems. With State Farm's lead, and the help of 22 industry partners, the schools are participating in a Service-Learning program that revamps school auto repair shops with cutting-edge technology, new curriculum, equipment, supplies, vehicles and professional development for teachers. Philadelphia's students aren't the only ones who win—the auto repair industry is facing a critical shortage of quality entry-level employees, and can't wait for these students to enter the job market.

"As a member of the Excel Tech Craft Advisory Board, I see the positive results Service-Learning has on the students and its importance to the collision repair industry."

— Jeff Gubicza, Faulkner Organization Body Shop Operations Manager

Experience is the Best Teacher

Learning through experience is the principle behind school-based Service-Learning—an innovative teaching method that integrates academic studies with community service to develop leadership potential, provide workplace skills and instill civic responsibility. Research shows that when students are involved in high quality Service-Learning they make gains on achievement tests, complete their homework more often and increase their grade-point averages. That's why State Farm supports Service-Learning programs coast-to-coast, investing in the lives and futures of young people.

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— Dr. Reban Yarmus, School Principle

INTRODUCING SERVICE-LEARNING MAKES A DRAMATIC DIFFERENCE*

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Students bound for post secondary education	40%	62%

*Results of study at Putnam High School, Springfield, MA



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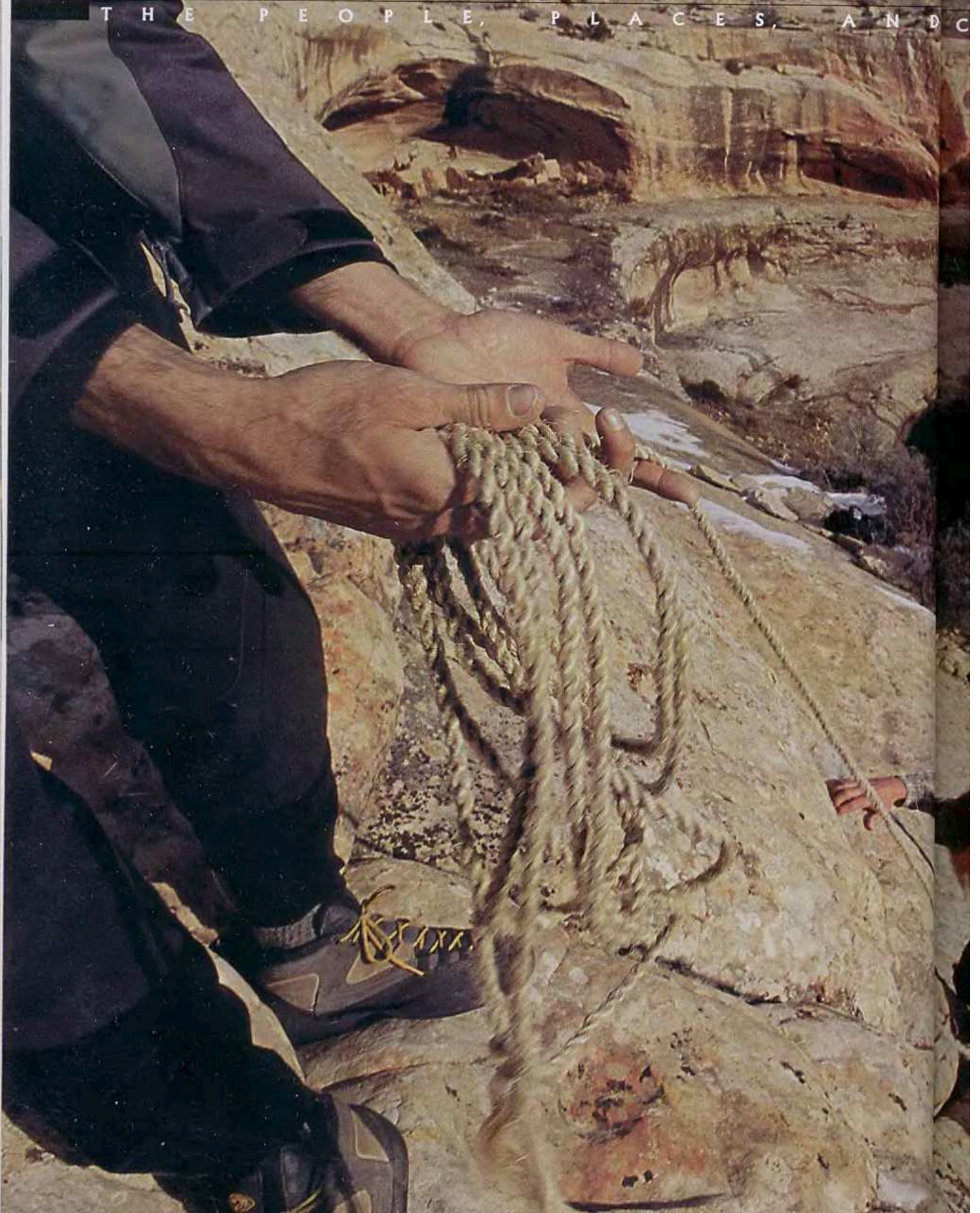
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GEOGRAPHY

THE PEOPLE, PLACES, AND CULTURES



GRAPHICA

CREATURES OF OUR UNIVERSE

CULTURE

Unraveling a Mystery

Did the Anasazi use ropes to reach cliffside homes?

Some of the cliff dwellings built by the Anasazi people more than 700 years ago are so inaccessible that today only rock climbers using ropes can reach them. That's what got a group of climbing Anasazi buffs wondering: Did the ancients use ropes too? And, if so, how did they make them?

"I'm always amazed by the questions we archaeologists don't think to ask," says University of Colorado Anasazi expert Richard Wilshusen. "As far as I know, nobody has ever studied this problem."

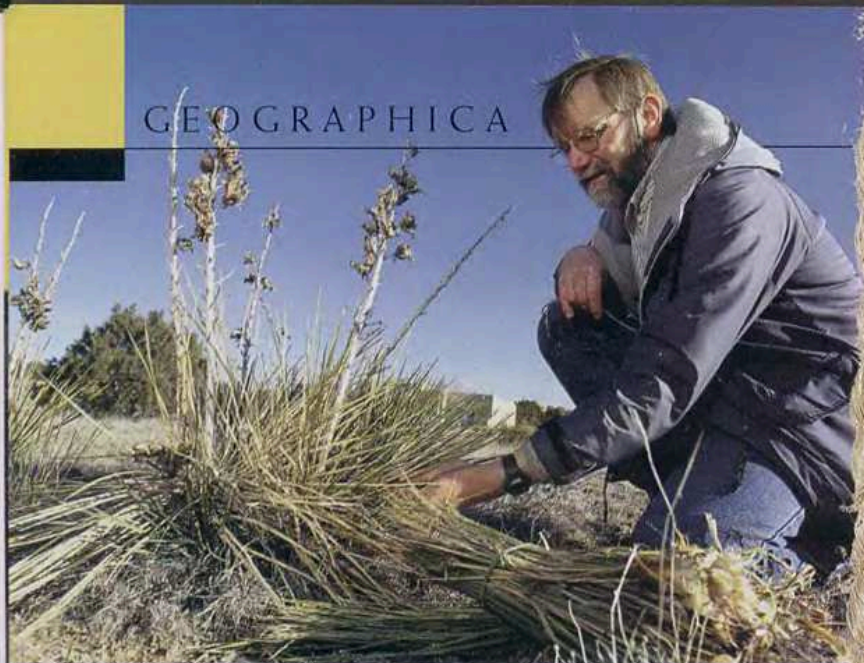
Until now. Remains of the Anasazi's aeries dot the Four Corners, where Utah, Colorado,

Arizona, and New Mexico meet. Archaeologists have long known that the Anasazi used log ladders (tree trunks with notched footholds) as well as hand-and-toe trails (staircases carved into cliff faces with quartzite stones) to gain access to the homes they built in natural alcoves, many of them hundreds of feet up sandstone cliffs.

Yet to climbers who've spent years navigating the cliffs of Anasazi country, many

Climber Vaughn Hadenfeldt (below) scales a cliff east of Comb Ridge in southern Utah using a rope especially made to mimic cords the Anasazi produced.

BILL HATCHER



BILL HATCHER (ABOVE AND SERIES AT RIGHT); MARK THIESSEN, NGS (ROPE)

dwelling seem unreachable by those means alone.

Excavations have yielded samples of cord the Anasazi produced for countless useful items, from sandals to rabbit snares, using fibers from wild plants like yucca and dogbane, and even human hair. Over the past 16 years, Museum of New Mexico archaeologist Eric Blinman (above) has taught himself to make yucca cordage that mirrors surviving Anasazi examples, some of which are stout enough to qualify as rope.

But could such cord have been used for climbing? Last winter Blinman spun two 30-foot lengths of yucca rope, one a quarter-inch in diameter, the other three-eighths of an inch (see sidebar). To test the thicker rope's strength, Vaughn Hadenfeldt, a wilderness guide based in Bluff, Utah, used it to climb a precipice studded with dwellings in southeastern Utah. "It handles a lot stiffer and more abrasive than nylon," Hadenfeldt reported. "I hung from it, even bounced up and down. I was surprised how strong it felt."

Hadenfeldt concluded that the natural-fiber rope (right) probably wouldn't be strong enough to hold

a climber's fall. "But I'd feel plenty safe hanging on it."

The Anasazi-style ropes then went to the product-testing lab of outdoor-gear retailer REI in Kent, Washington, where engineer Steve Nagode strained pieces of each of Blinman's cords to its breaking point. On average, the thicker rope segments broke at 456 pounds of strain, the thinner at 233 pounds.

That's only about a fifth as strong as the high-tech synthetic ropes used today. But these yucca ropes are comparable in strength to the hemp and manila cordage mountaineers used before the advent of nylon ropes in the 1940s.

If the Anasazi counted on ropes to help them stay safe, as climbers do today, they took big risks: A 20-foot fall would likely break the three-eighths-inch rope Blinman crafted. But the ancients may have used such cords to haul building materials and other supplies or to assist less sure-footed residents into their cliffside homes. Even that would have been scary, but, as Blinman wryly notes, the Anasazi didn't have safety inspectors.

—David Roberts

A Recipe for Rope

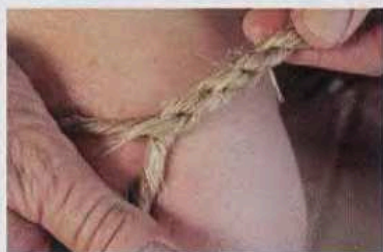
Eric Blinman starts by gathering yucca leaves from plants growing in his Santa Fe neighborhood (left), then produces cords using techniques he's developed through his study of Anasazi artifacts and century-old reports on the culture of the Anasazi's descendants, the Pueblo Indians.



Plant After simmering the narrow yucca leaves for 24 hours, Blinman uses a deer bone tool (similar to what the Anasazi likely used) to separate the plant's tough, threadlike fibers from its pulp.



Fiber After extracting fibers from the pulpy residue, Blinman gathers individual strands into bundles for spinning. "Once I have the raw materials prepared," he says, "I can make 30 feet of three-eighths-inch cord in ten hours."



Cord Using his bare thigh as a work surface, Blinman spins two bundles of fibers as tightly as he can. Once he lets go, the bundles naturally twist themselves together as rope. Thread can be made by spinning just a few fibers.

WEBSITE EXCLUSIVE Find links and resources selected by our Research Division at nationalgeographic.com/magazine/resources/0409.

CONSERVATION

Making Book
on Birds


It was a race for survival. Beginning last spring, thousands of people placed bets on which shy albatross would be the first to cross the finish line of a 6,000-mile annual migration from Australia to the Cape of Good Hope in Africa. Dubbed the Big Bird Race, the event was a fund-raiser to help threatened seabirds.

More than 300,000 seabirds die each year when they get tangled up by longlines—

commercial fishing lines with miles of hooks. The race's promoters hope to encourage nations with fishing fleets to weight longlines so they sink, reducing accidental snagging.

Celebrities such as David Attenborough and Queen Noor adopted and raced 18 juvenile shy albatrosses, which were fitted with satellite transmitters before starting their annual migration on April 27. At press time, though no winner had been announced, the event was expected to yield hundreds of thousands of dollars. Bettors were exhorted to donate their winnings to a special fund to aid seabirds, says Australian conservationist Tim Nevard, ensuring that birds, not bettors, will come out the winners. —*John L. Eliot*

JASON EDWARDS, BIO-IMAGES (ABOVE); U.S. PATENT AND TRADEMARK OFFICE (BELOW); MONTAGUE LYON COLLECTION, MISSOURI HISTORICAL SOCIETY

INVENTIONS

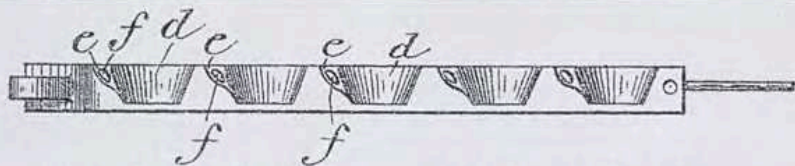
Who Scooped the
First Ice-Cream Cone?

Most ice-cream cones end the same way, melting sweetly on the tongue. But how did the first ice-cream cone begin? Tales of the cone's invention converge on one spot: the 1904 World's Fair in



St. Louis, Missouri (below). In one story, an ice-cream vendor ran out of serving dishes and was rescued by Ernest Hamwi, a Syrian immigrant selling Middle Eastern waffles at the next stand. Another Syrian immigrant claimed it was his idea to roll a hot waffle, let it harden, then plop in the ice cream. Yet a third claimant was former circus acrobat Charles Menches, who is said to have peeled away one side of an ice-cream sandwich to make an improvised vase for flowers, then molded the other side to hold the remaining ice cream. Hamwi and Menches went on to create ice-cream-cone empires.

One earlier claim gets lost in the hubbub: Five months before the World's Fair, a patent was



awarded to candymaker Italo Marchionni: "I claim as my invention . . . a molding apparatus [patent drawing above] for creating ice cream cups and the like." If only he'd said cones. —*Joshua Korenblat*

World's Fair Legacies

Eiffel Tower, Paris 1889 Despite its record height and panoramic views, critics deemed the tower a bit unsightly.

Ferris wheel, Chicago 1893 Its creator took "the Eiffel Tower, put it on a pivot, and made it move."

Typewriter, Chicago 1893 Crowds were wowed—by the inventor's red-haired, quick-typing secretary.

Cell phone, St. Louis 1904 A telegraphy business showcased the first wireless phone.

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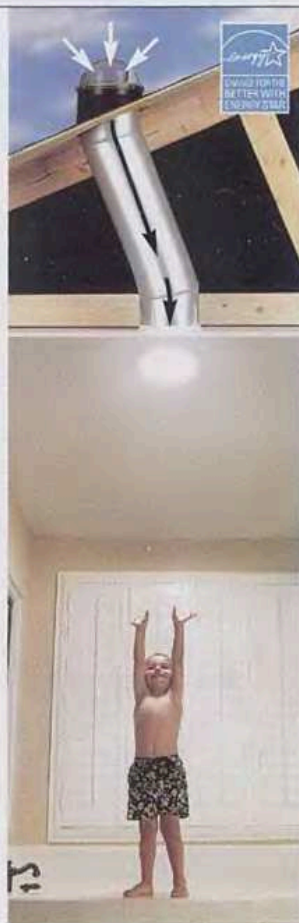
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RESTORATION

David's 500-Year Facial

Cotton swabs and mud packs lift centuries of grime

September 8, 1504: "David," Michelangelo Buonarroti's monument to the biblical shepherd who slew the giant Goliath, is unveiled in Florence's Piazza della Signoria. This month: The statue celebrates its 500th birthday with a fresh face, after a restoration project that

included years of tests—3-D laser modeling, CT scans, and ultraviolet fluorescence mapping—and hundreds of hours of cleaning. Only cotton swabs and distilled water were used on the face (above); poultices of cellulose pulp and clay helped remove contaminants from the body. While

some critics feared the anniversary cleaning might damage the statue, few Italians objected.

More than a million people swarm each year to the Galleria dell'Accademia, where the 17-foot-tall masterpiece has resided since 1873. The museum stayed open during the restoration, so Italian conservator Cinzia Parnigoni did her job in public. "Keeping my concentration in front of people was not easy," Parnigoni says, "but working on 'David' was a priceless privilege."

—Marco Pinna
NGM ITALY

A Marble Hero's Hard Life

1512 Lightning strikes the base.

1527 The left arm is broken during riots against Florence's ruling Medici family.

1808-1815 The statue is coated with wax for weatherproofing.

1843 "David" is cleaned with steel brushes and an acid solution.

1991 A vandal hits a foot with a hammer, damaging a toe.

ANIMAL BEHAVIOR

How Pigeons Really Get Home

Homing pigeons are known for their uncanny internal compass, yet a new study reveals that sometimes the birds get home the same way we do: They follow the roads.

Tim Guilford and Dora Biro at England's Oxford University followed pigeons in Oxford over a three-year period, using tiny tracking devices equipped with global positioning system technology developed by Swiss and Italian colleagues. "We expected the birds to take the most energy-efficient route," says Guilford. "And we were interested in



finding out what land features they used to do that."

What they discovered was surprising. Within ten kilometers of home, the pigeons relied less on their well-known talents for decoding the sun's position or deciphering the Earth's magnetic

field to help them navigate. Instead they opted for a habitual route that followed linear features in the landscape, such as roads, rivers, railways, and hedge lines—even when it wasn't the most direct way home. "It was almost comical," says Guilford. One pigeon followed a road to a roundabout, then exited onto a major road that led to a second roundabout. Others flew down the River Thames, only to make a distinct turn at a bridge.

Guilford suggests that sticking to a memorized, linear route may actually make homing more reliable—and easier. "It made me smile to see it," says Guilford. "You can imagine yourself flying along a road doing the same thing." —Whitney Dangerfield

My Seven



What We Learn From Deadly Quakes

Sálvano Briceño *Director of the UN's Secretariat for Disaster Reduction*

The numbers for last year are in, and they're grim: nearly 30,000 people killed by earthquakes in 2003, the deadliest year in more than a decade. Sálvano Briceño, who tracks disasters worldwide, is all too aware that many of last year's deaths could have been avoided. Here's his list of killer quakes from the past 30 years, and the lessons we've learned from them.

1 Bam, Iran (2003)
Many of the 26,200 who perished were crushed by poorly constructed buildings doomed to collapse in a seismic hot spot like Iran. Lesson learned: Develop and enforce building codes in areas where earthquakes are common.

2 Molise, Italy (2002) Of the 29 victims, 26 were children at school. Lesson learned: Take special precautions to safeguard schools and other public buildings.

3 Gujarat, India (2001) After 20,000 died in one of the most devastating earthquakes in India's history, the nation overhauled its disaster-management strategy, reorganizing responsibility so that some was given to officials at the local level. Lesson learned: When local authorities are better prepared, public safety improves.



NATALIE BIRABEN (TOP LEFT); TOM WAGNER, CORBIS SABA

4 Kobe, Japan (1995)
The disaster (above) claimed more than 5,500 lives and caused a stunning \$100 billion in economic losses. Lesson learned: Even wealthy nations suffer dramatically when a deadly quake hits.

5 Northridge, California (1994) Of the property lost, valued at \$44 billion, a third was insured—a high percentage. Lesson learned: Quake

insurance can reduce vulnerability and speed disaster recovery.

6 Mexico City, Mexico (1985)
After this earthquake, which killed at least 9,500, the government created an agency for disaster-preparedness that brought together scientists, engineers, and government officials. Lesson learned: Nations need to plan for quakes ahead of time, instead of waiting until disaster strikes to respond.

7 Tangshan, China (1976)
Recovery from the earthquake and its staggering death toll (255,000) was delayed by political power struggles and the death of Mao. Lesson learned: Competing priorities can divert attention from disasters.

FEATURE FILM See our giant-screen movie *Forces of Nature* to experience the havoc of a quake. For a preview go to nationalgeographic.com/forcesofnature.

Do It Yourself

GLOBAL CHANGE (SEE PAGE 2)

GO THERE

See the Beauty in Prehistoric Climate Change

The landscapes in some of the hottest travel destinations were shaped by a series of nasty cold spells. During the most recent ice age, from about 70,000 to 11,500 years ago, ice sheets up to 13,000 feet thick moved across much of North America and Eurasia. To see how that ice altered the Earth, go to:

- **Ireland** Distinctive clusters of elongated, parallel hills called drumlins (below) were formed by ice sheets as they flowed over the landscape.
- **The Alps** Glaciers sculpted steep ridges and peaks like the Matterhorn.
- **Yosemite** Repeated glacial scouring created the park's U-shaped valleys.



JOE CORNISH, THE NATIONAL TRUST

TRY IT AT HOME

Watch the Birdy—For Science

As the world's climate warms, are animals and plants shifting their ranges closer to the poles or to higher elevations? You don't have to be a scientist to join the quest for answers. Backyard naturalists can take part in Project FeederWatch, a study run by Cornell Lab of Ornithology and Bird Studies Canada to monitor the abundance and

distribution of birds in North America. Following a simple protocol, participants can report species they see at feeders by phone or at the FeederWatch website. "Anybody can sign up," says project leader David Bonter. "Some of our best counters are schoolchildren." Using FeederWatch data, researchers have already documented the drift



JOEL SARTORE

northward of Carolina wrens and red-bellied woodpeckers. To join Project FeederWatch, call 1-800-843-2473 or go to birds.cornell.edu/pfw.

PICKS

3 tips

Every year humans release billions of tons of carbon dioxide (CO₂) into the atmosphere, a major contributor to global warming. You might be surprised by how you can reduce your share. **Eileen Claussen**, president of the Pew Center on Global Climate Change, offers three easy ways to cut CO₂ emissions—and save money.

■ **Use fluorescent lightbulbs** Replacing just one oft-used incandescent lightbulb with a compact fluorescent one reduces annual CO₂ output by a few hundred pounds. That's because most power comes from burning fossil fuels.

■ **Turn down the thermostat on your water heater** Many of the thermostats on water heaters are set too high, at about 140°F. Turning yours down to 120° means 1,200 fewer pounds of CO₂ a year.

■ **Drive a fuel-efficient car** A car rated at 32 miles per gallon driven 15,000 miles a year emits around two tons less CO₂ than a car that gets average gas mileage (about 22 mpg).

WEBSITE EXCLUSIVE

Test your climate-change knowledge with an interactive quiz at nationalgeographic.com/magazine/0409.



Who Knew?

PARTICLE PHYSICS

Strung Out

*Everything—even you—
is made of little strings*

Physicists may have a knack for mind-boggling theories, complicated equations, and utterly confounding jargon, but they actually love simplicity. They assume reality is simple at its foundation. That's why they aren't comfortable with their own standard model of particle physics. This model describes the characteristics and interactions of 57 (at last count) different particles—from electrons to quarks to muons—that make up everything in the universe. (When the muon was discovered, a physicist famously asked, "Who ordered that?")

Joe Lykken, a physicist at Fermilab near Chicago, points out: "It seems absurd that the most elementary piece of the universe should come in 57 varieties." It's as though Heinz is running the show.

The search for an underlying reality has led many physicists to embrace string theory. This theory imagines that every substance in the universe is made of just one thing: tiny vibrating strings. At different resonances these strings create the 57 different particles—and everything else.

The theory also has the unusual feature (some might call it a drawback) of requiring at least nine spatial dimensions, six of

which are not noticeable to those of us living in a three-dimensional world.

At the moment the theory has no experimental support. No one has seen strings. They'd be way too small, by a factor of many trillions. As for the hidden dimensions, they're wherever you left the car keys.

But physicists are desperate to scrape up evidence of strings because they would, says Lykken, "reduce extremely complicated physics down to fairly simple equations that you can write on a single piece of paper." Signs of extra dimensions might emerge when physicists collide particles in giant accelerators and tally up the energy at the end. If any is missing, it might have leaked into another dimension.

Brian Greene, author of the best-selling book *The Fabric of the Cosmos*, thinks it might be possible to discover evidence of strings in the cosmic microwave background (CMB)—radiation visible everywhere in the sky. (The CMB is the cooled, diluted afterglow that scientists consider the imprint of the big bang that formed the universe.)

The expansion of the universe has stretched out the CMB, and in it we might see slight variations of temperatures in space that would be consistent with string theory. "We just need to learn how to read the message that strings have left for us," Greene says.

Not easily done, to be sure. Merely finding something consistent with string theory is not the same thing as proving it's

true, and skeptics will need a lot of convincing. But Greene points out that string theory is still in its youth. He says, "Had you gone up to Mr. Stradivarius when he had a block of wood on the table and said, 'Play that violin,' he would have said you were a little early."

At the very least, string theory is a great intellectual achievement. If someone told you to create a universe from scratch, these strings would come in mighty handy.

—Joel Achenbach

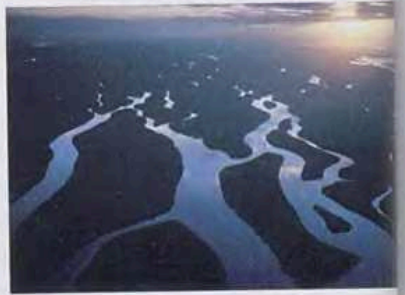
WASHINGTON POST STAFF WRITER

Making it Snappy

A lot of big science is happening in some very small places. While some scientists dream of tiny vibrating strings, others are actually tracking the microscopic dance of particles inside atoms. This year physicists in Germany and Austria used extreme ultraviolet rays to calculate the time it takes—about 150 attoseconds—for an electron to zoom once around the nucleus of a hydrogen atom. An attosecond is one quintillionth of a second (10^{-18} seconds). To put that in perspective, an electron could orbit a nucleus a million billion times during one blink of an eye. That kind of split-second vision is already letting scientists watch electrons jump around, creating and breaking the bonds that hold molecules together. The next frontier: the zeptosecond (10^{-21} seconds).

—Heidi Schultz

WEBSITE EXCLUSIVE For more about string theory, and for links to Joel Achenbach's work, go to Resources at nationalgeographic.com/magazine/0409.



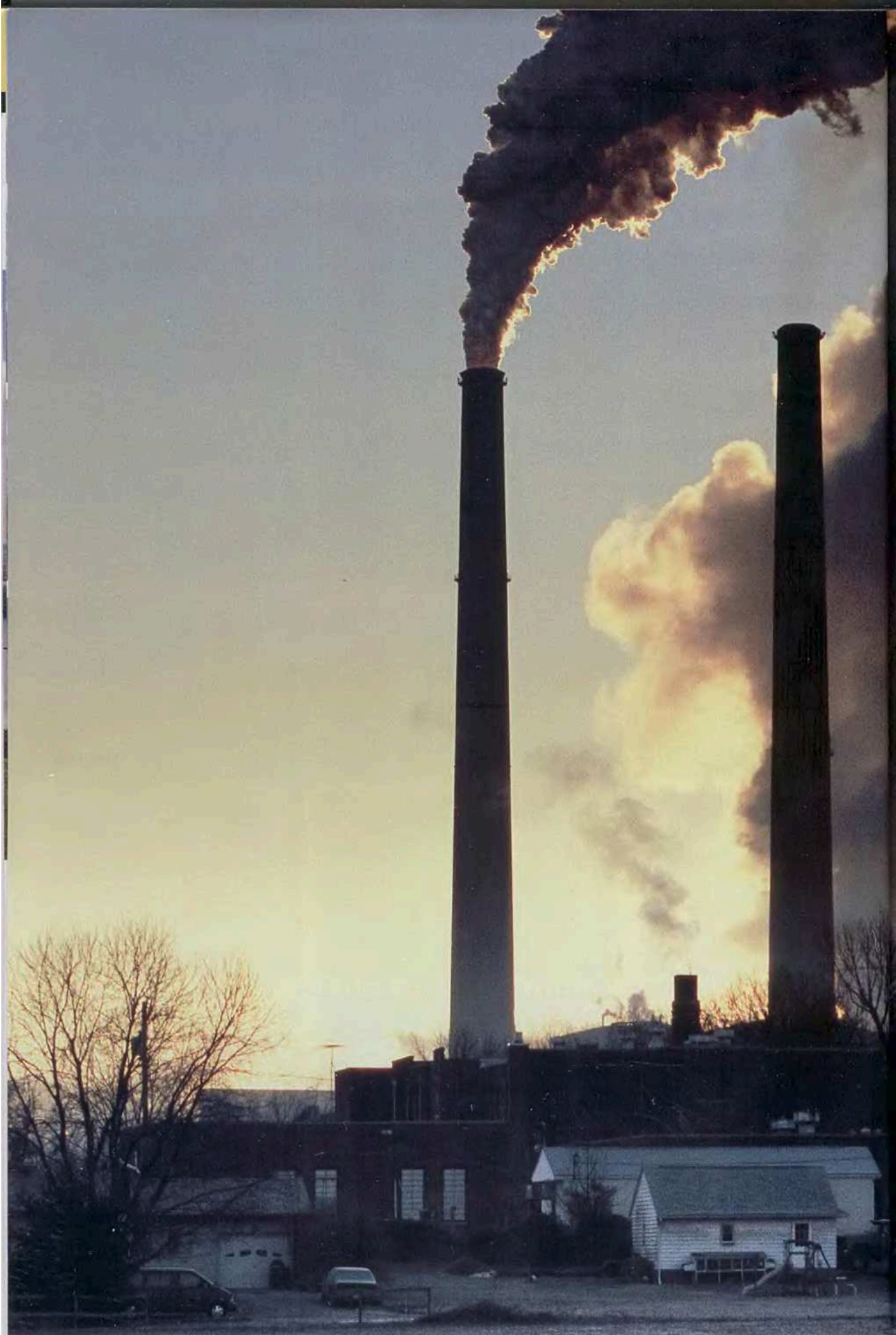
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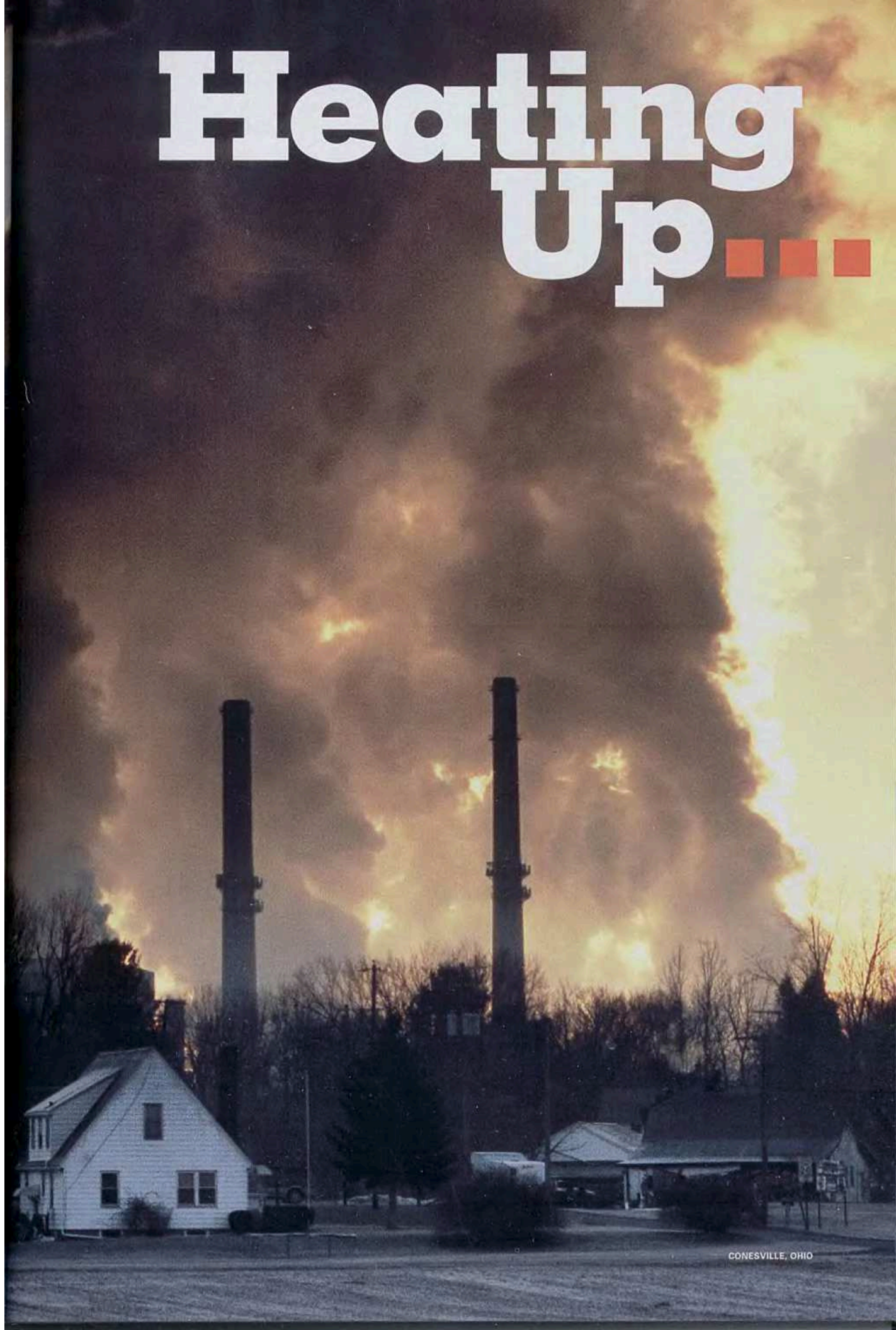
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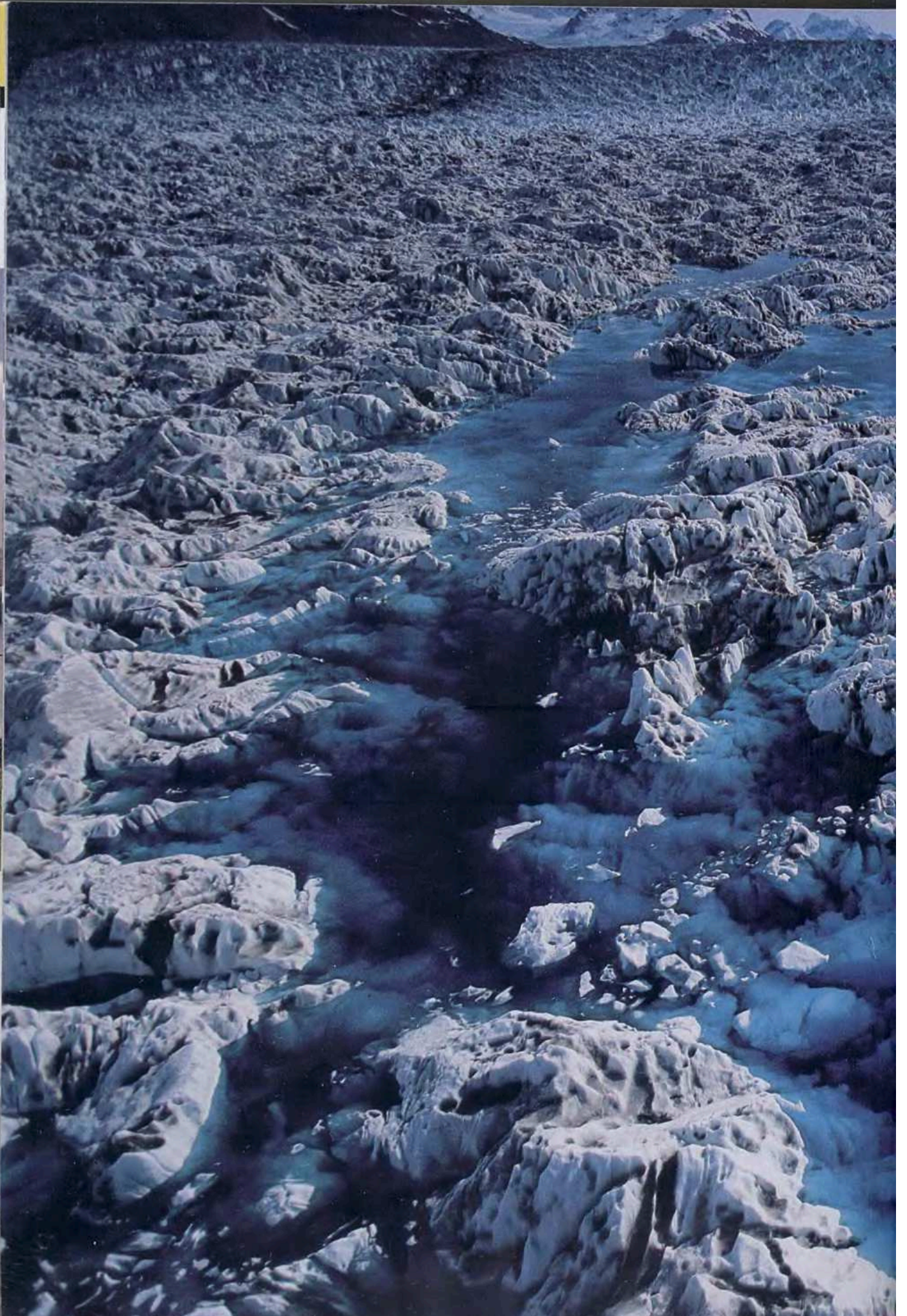
What in the World Is Going On?



Heating Up ■■■

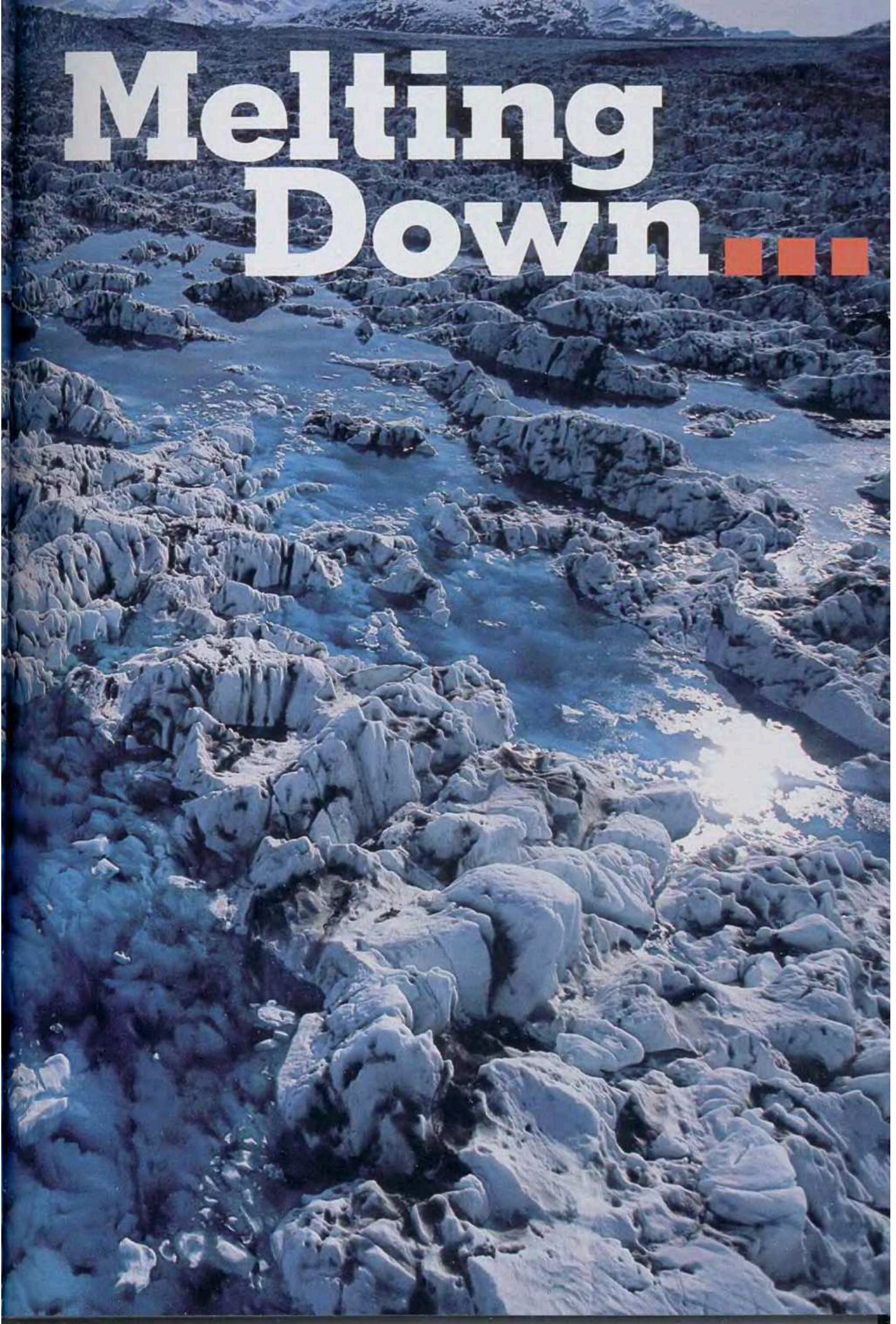


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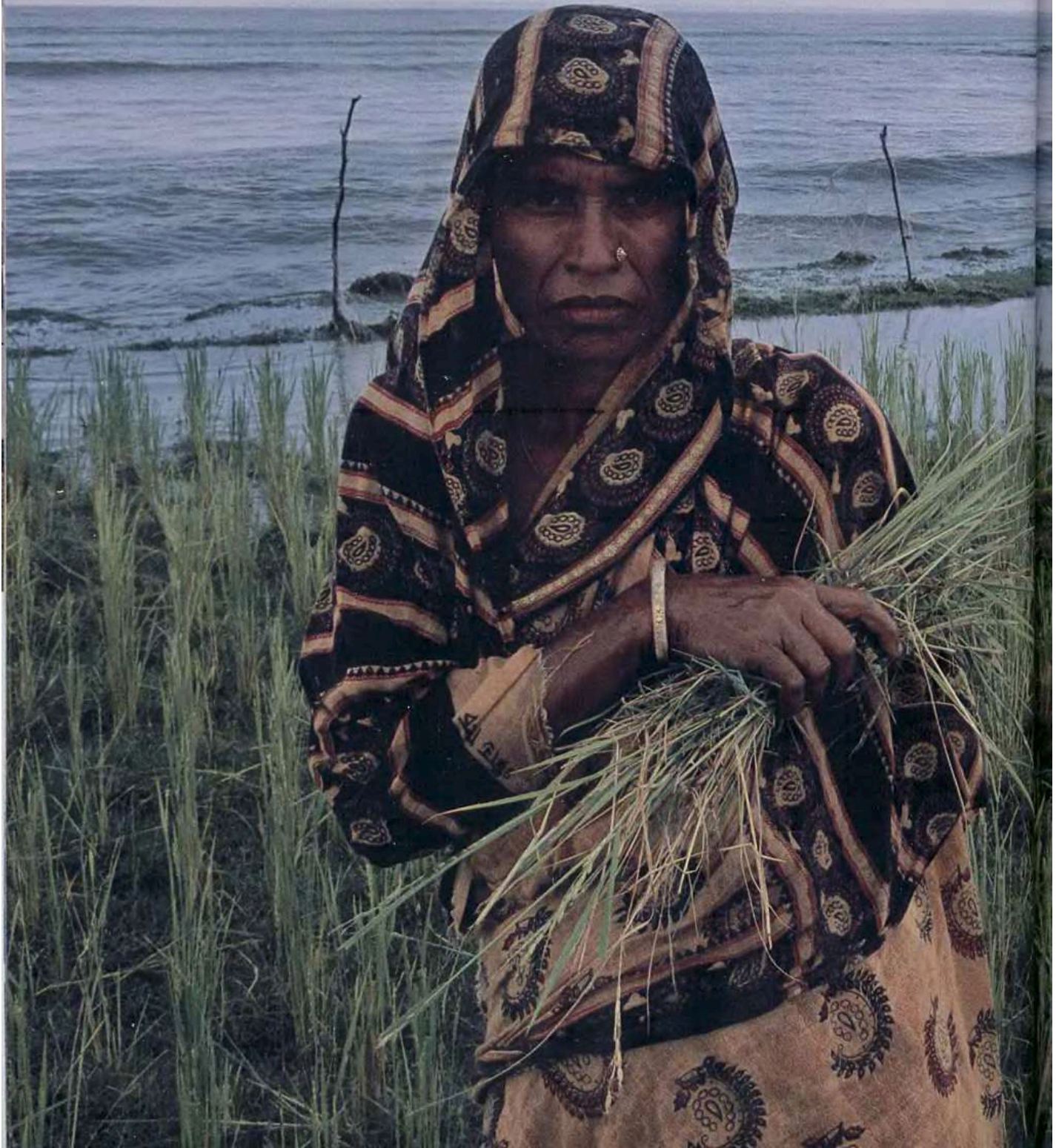


COLUMBIA GLACIER, ALASKA

Melting Down



"Things that normally




**happen in geologic time
are happening during the
span of a human lifetime."**



Swells rise in the Bay of Bengal and splash into Nurzahan Bibi's rice field, which—as global temperatures rise and sea level climbs—becomes an ever more precarious means of support for the widowed Bangladeshi. Alaska's rapidly shrinking glaciers (like Columbia Glacier, pages 6-7) are significant contributors to rising seas. There's little doubt that greenhouse gases released by industry, agriculture, automobiles, and coal-fired electric generation (pages 4-5) are a key factor in changing Earth's climate.

DHAL CHAR, BANGLADESH

S I G N S F R O M E A R T H

 Global warming can seem too remote to worry about, or too uncertain—something projected by the same computer techniques that often can't get next week's weather right. On a raw winter day you might think that a few degrees of warming wouldn't be such a bad thing anyway. And no doubt about it: Warnings about climate change can sound like an environmentalist scare tactic, meant to force us out of our cars and cramp our lifestyles.

Comforting thoughts, perhaps. But turn to "GeoSigns," the first chapter in our report on the changing planet. The Earth has some unsettling news.

From Alaska to the snowy peaks of the Andes the world is heating up right now, and fast. Globally, the temperature is up 1°F over the past century, but some of the coldest, most remote spots have warmed much more. The results aren't pretty. Ice is melting, rivers are running dry, and coasts are eroding, threatening communities. Flora and fauna are feeling the heat too, as you'll read in "EcoSigns." These aren't projections; they are facts on the ground.

The changes are happening largely out of sight. But they shouldn't be out of mind, because they are omens of what's in store for the rest of the planet.

Wait a minute, some doubters say. Climate is notoriously fickle. A thousand years ago Europe was balmy and wine grapes grew in England; by 400 years ago the climate had turned chilly and the Thames froze repeatedly. Maybe the current warming is another natural vagary, just a passing thing?

Don't bet on it, say climate experts. Sure, the natural rhythms of climate might explain a few of the warming signs you'll read about in the following pages. But something else is driving the planet-wide fever.

For centuries we've been clearing forests and burning coal, oil, and gas, pouring carbon dioxide and other heat-trapping gases into the atmosphere faster than plants and oceans can soak them up (see "The Case of the Missing Carbon," February 2004). The atmosphere's level of carbon dioxide now is higher than it has been for hundreds of thousands of years. "We're now geological agents, capable of affecting the processes that determine climate,"



G E O S I G N S

P A G E 1 2

E C O S I G N S

P A G E 3 4

T I M E S I G N S

P A G E 5 6

says George Philander, a climate expert at Princeton University. In effect, we're piling extra blankets on our planet.

Human activity almost certainly drove most of the past century's warming, a landmark report from the United Nations Intergovernmental Panel on Climate Change (IPCC) declared in 2001. Global temperatures are shooting up faster than at any other time in the past thousand years. And climate models show that natural forces, such as volcanic eruptions and the slow flickers of the sun, can't explain all that warming.

As CO₂ continues to rise, so will the mercury—another 3°F to 10°F by the end of the century, the IPCC projects. But the warming may not be gradual. The records of ancient climate described in "TimeSigns" suggest that the planet has a sticky thermostat. Some experts fear today's temperature rise could accelerate into a devastating climate lurch. Continuing to fiddle with the global thermostat, says Philander, "is just not a wise thing to do."


Already we've pumped out enough greenhouse gases to warm the planet for many decades to come. "We have created the environment in which our children and grandchildren are going to live," says Tim Barnett of the Scripps Institution of Oceanography. We owe it to them to prepare for higher temperatures and changed weather—and to avoid compounding the damage.

It won't be easy for a world addicted to fossil fuels to limit emissions. Three years ago the United States spurned the Kyoto Protocol, citing cost. But even Kyoto would barely slow the rise in heat-trapping gases. Controlling the increase "would take 40 successful Kyotos," says Jerry Mahlman of the National Center for Atmospheric Research. "But we've got to do it."

The signs of warming in the following pages are striking enough, but they are just a taste of the havoc the next century could bring. Can we act in time to avert the worst of it? The Earth will tell.

Tim Appenzeller · *Senior Editor, Science*

Dennis R. Dimick · *Senior Editor, Environment and Technology*



In the mid-1800s the Unteraar Glacier was gouging its way through this steep valley of Switzerland's central Alps. It has since crept back to higher elevation, receding more than a mile as temperatures have risen. In much of Europe, Alaska, South America, and elsewhere, the story is the same.

BY DANIEL GLICK

PHOTOGRAPHS BY PETER ESSICK

If we don't have it, we don't need it," pronounces Daniel Fagre as we throw on our backpacks. We're armed with crampons, ice axes, rope, GPS receivers, and bear spray to ward off grizzlies, and we're trudging toward Sperry Glacier in Glacier National Park, Montana. I fall in step with Fagre and two other research scientists from the U.S. Geological Survey Global Change Research Program.

They're doing what they've been doing for more than a decade: measuring how the park's storied glaciers are melting.

So far, the results have been positively chilling. When President Taft created Glacier National Park in 1910, it was home to an estimated 150 glaciers. Since then the number has decreased to fewer than 30, and most of those remaining have shrunk in area by two-thirds. Fagre predicts that within 30 years most if not all of the park's namesake glaciers will disappear.

"Things that normally happen in geologic time are happening during the span of a human lifetime," says Fagre. "It's like watching the Statue of Liberty melt."

Scientists who assess the planet's health see indisputable evidence that Earth has been getting warmer, in some cases rapidly. Most believe that human activity, in particular the burning of fossil fuels and the resulting buildup of greenhouse gases in the atmosphere, have influenced this warming trend. In the past decade scientists have documented record-high average annual surface temperatures and have been observing other signs of change all over the planet: in the distribution of ice, and in the salinity, levels, and temperatures of the oceans.

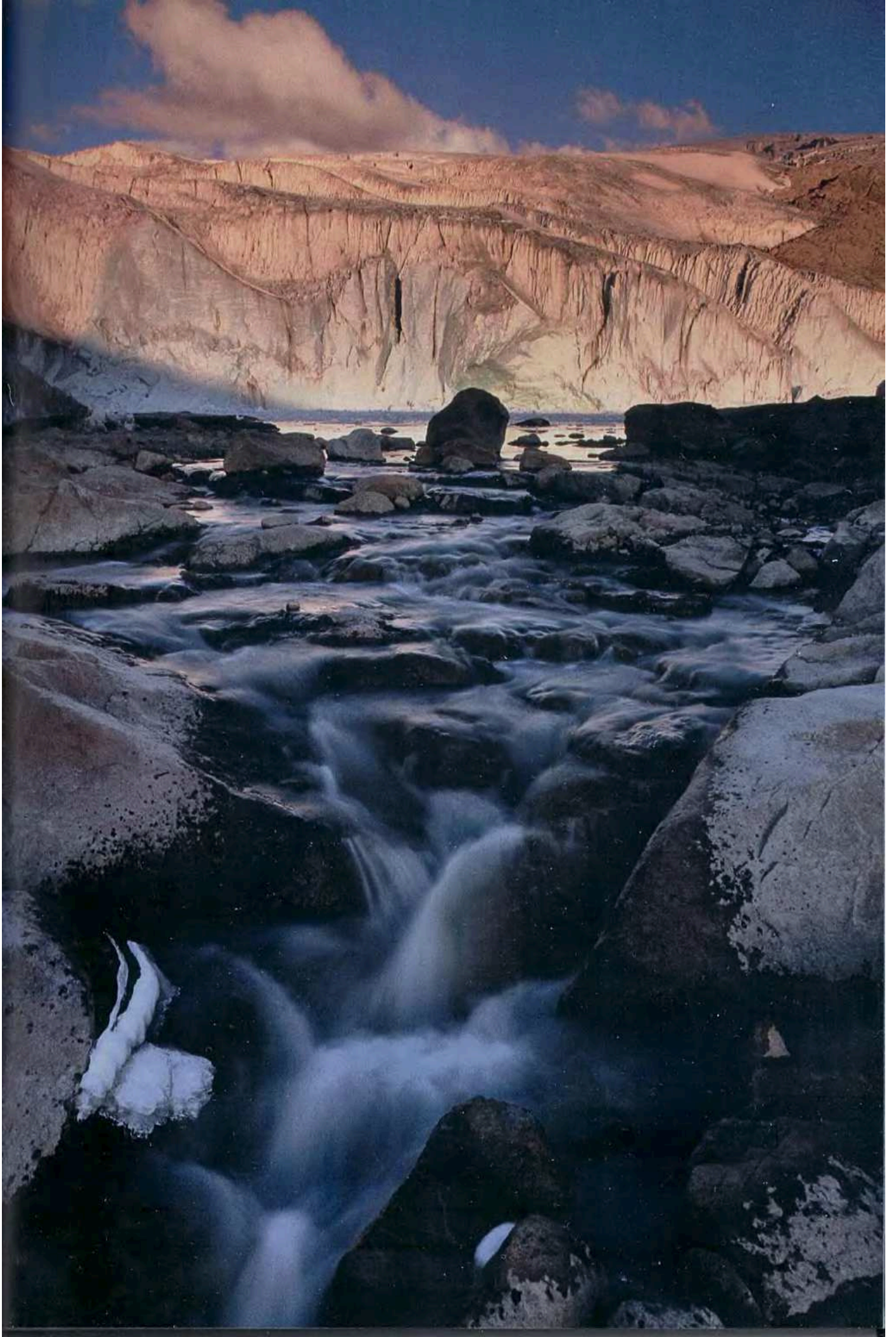
"This glacier used to be closer," Fagre declares as we crest a steep section, his glasses fogged from exertion. He's only half joking. A trailside sign notes that since 1901, Sperry Glacier has shrunk from more than 800 acres to 300 acres. "That's out of date," Fagre says, stopping to catch his breath. "It's now less than 250 acres."

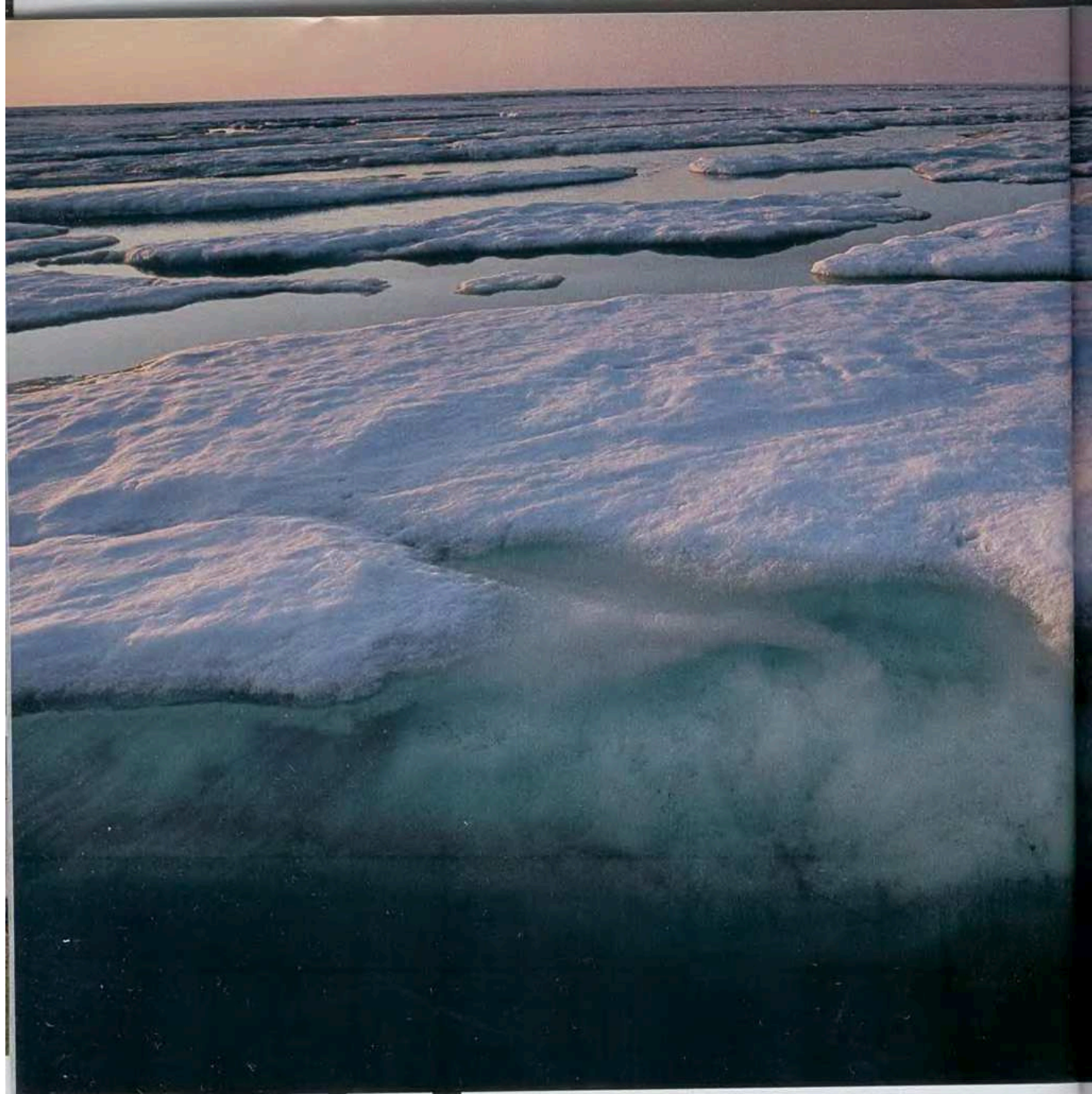
Everywhere on Earth ice is changing. The famed snows of Kilimanjaro have melted more than 80 percent since 1912. Glaciers in the Garhwal Himalaya in India are retreating so fast that researchers believe that most central and eastern Himalayan glaciers could virtually disappear by 2035. Arctic sea ice has thinned significantly over the past half century, and its extent has declined by about 10 percent in the past 30 years. NASA's repeated laser altimeter readings show the edges of Greenland's ice sheet shrinking. Spring freshwater ice breakup in the Northern Hemisphere now occurs nine days earlier than it did 150 years ago, and autumn freeze-up ten days later. Thawing permafrost has caused the ground to subside more than 15 feet in parts of Alaska. From the Arctic to Peru, from Switzerland to the equatorial glaciers of Irian Jaya in Indonesia, massive ice fields, monstrous glaciers, and sea ice are disappearing, fast.

When temperatures rise and ice melts, more water flows to the seas from glaciers and ice caps, and ocean water warms and expands in volume. This combination of effects has played the major role in raising average global sea level between four and (Continued on page 19)

Going, Going . . .

Peru's Quelccaya ice cap is the largest in the tropics. If it continues to melt at its current rate—contracting more than 600 feet a year in some places—it will be gone by 2100, leaving thousands who rely on its water for drinking and electricity high, dry, and in the dark.





Thin Ice in the Arctic

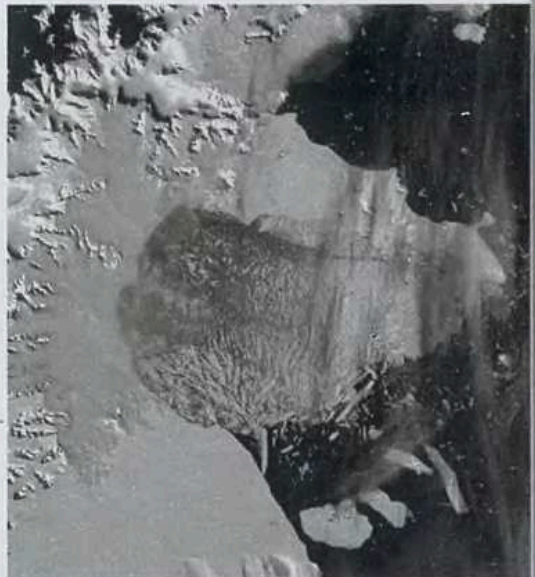
The annual breakup of sea ice (above and opposite) off the coast of Alaska happens weeks earlier than it once did. Since 1978 the area of perennial Arctic sea ice has decreased by 9 percent per decade, but the degree to which the ice has thinned has been harder to assess. Scientists using submarine sonar data documented a 40 percent thinning in the past 30 years. Others have put the estimate at about 15 percent. Some predict that the ice could be absent in summer by 2100.



BEAUFORT SEA, ALASKA (ABOVE AND BELOW)

A Coastline Redrawn

The epic collapse of a 1,250-square-mile section of the Larsen Ice Shelf took just over a month in early 2002. Melt ponds—visible as dark striations on the floating ice shelf (right) presaged the impending break-up (below right). Scientists are monitoring what effect the further disintegration of Larsen—and of other Antarctic ice shelves—might have on the continent's glaciers. Without ice shelves to act as dams, those glaciers might migrate faster toward the coast, ultimately contributing to rising sea level.



ANTARCTIC PENINSULA, NATIONAL SNOW AND ICE DATA CENTER (TOP AND ABOVE)





MALE, MALDIVES

Encroaching Seas

Waves hammer a seawall in Male (above), capital of the Maldives, a nation of islands in the Indian Ocean that tops out at an elevation of less than eight feet. As ocean warming forces sea level to rise, the Maldives' continued existence is in doubt. In Shishmaref, an Inupiat island village in western Alaska, higher waves—a result of sea ice decline—have caused so much erosion that the village plans to relocate on the mainland. The ground where village elder Flora Weyiouanna dried seal meat last year is gone. "We were able to salvage the wood," she says.

SHISHMAREF, ALASKA



(Continued from page 14) eight inches in the past hundred years, according to the Intergovernmental Panel on Climate Change (IPCC).

Scientists point out that sea levels have risen and fallen substantially over Earth's 4.6-billion-year history. But the recent rate of global sea level rise has departed from the average rate of the past two to three thousand years and is rising more rapidly—about one-tenth of an inch a year. A continuation or acceleration of that trend has the potential to cause striking changes in the world's coastlines.

Driving around Louisiana's Gulf Coast, Windell Curole can see the future, and it looks pretty wet. In southern Louisiana coasts are literally sinking by about three feet a century, a process called subsidence. A sinking coastline and a rising ocean combine to yield powerful effects. It's like taking the global sea-level-rise problem and moving it along at fast-forward.

The seventh-generation Cajun and manager of the South Lafourche Levee District navigates his truck down an unpaved mound of dirt that separates civilization from inundation, dry land from a swampy horizon. With his French-tinged lilt, Curole points to places where these bayous,

in coastal Louisiana but around the world. Never before have so many humans lived so close to the coasts: More than a hundred million people worldwide live within three feet of mean sea level. Vulnerable to sea-level rise, Tuvalu, a small country in the South Pacific, has already begun formulating evacuation plans. Megacities where human populations have concentrated near coastal plains or river deltas—Shanghai, Bangkok, Jakarta, Tokyo, and New York—are at risk. The projected economic and humanitarian impacts on low-lying, densely populated, and desperately poor countries like Bangladesh are potentially catastrophic. The scenarios are disturbing even in wealthy countries like the Netherlands, with nearly half its landmass already at or below sea level.

Rising sea level produces a cascade of effects. Bruce Douglas, a coastal researcher at Florida International University, calculates that every inch of sea-level rise could result in eight feet of horizontal retreat of sandy beach shorelines due to erosion. Furthermore, when salt water intrudes into freshwater aquifers, it threatens sources of drinking water and makes raising crops problematic. In the Nile Delta, where many of Egypt's

"I've probably ordered more evacuations than any other person in the country."

swamps, and fishing villages portend a warmer world: his high school girlfriend's house partly submerged, a cemetery with water lapping against the white tombs, his grandfather's former hunting camp now afloat in a stand of skeleton oak snags. "We live in a place of almost land, almost water," says the 52-year-old Curole.

Rising sea level, sinking land, eroding coasts, and temperamental storms are a fact of life for Curole. Even relatively small storm surges in the past two decades have overwhelmed the system of dikes, levees, and pump stations that he manages, upgraded in the 1990s to forestall the Gulf of Mexico's relentless creep. "I've probably ordered more evacuations than any other person in the country," Curole says.

The current trend is consequential not only

crops are cultivated, widespread erosion and salt-water intrusion would be disastrous—since the country contains little other arable land.

In some places marvels of human engineering worsen effects from rising seas in a warming world. The system of channels and levees along the Mississippi effectively stopped the millennia-old natural process of rebuilding the river delta with rich sediment deposits. In the 1930s, oil and gas companies began to dredge shipping and exploratory canals, tearing up the marshland buffers that helped dissipate tidal surges. Energy drilling removed vast quantities of subsurface liquid, which studies suggest increased the rate at which the land is sinking. Now Louisiana is losing approximately 25 square miles of wetlands every

(Continued on page 27)

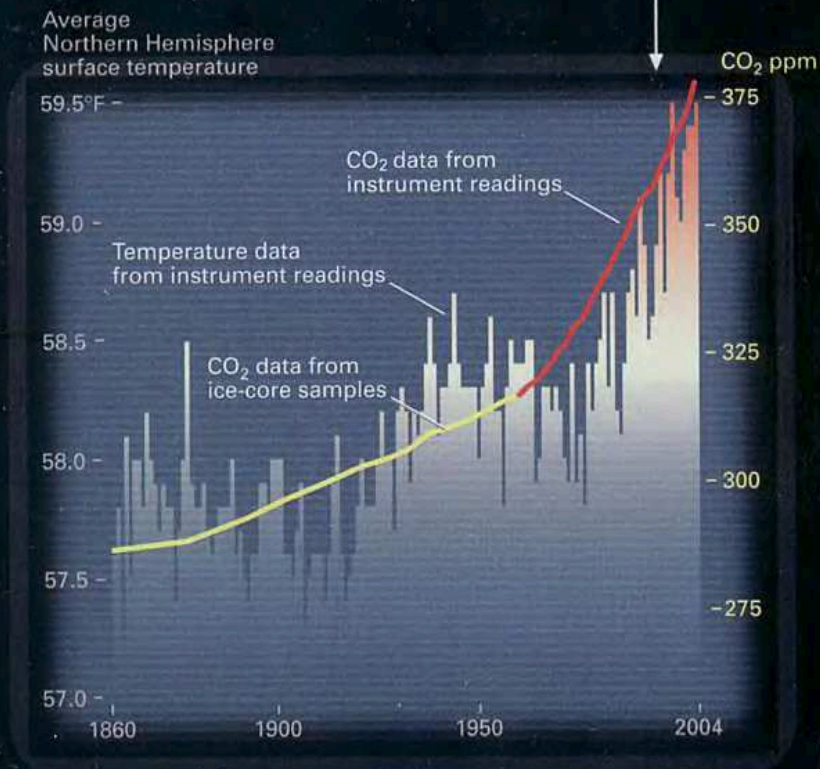
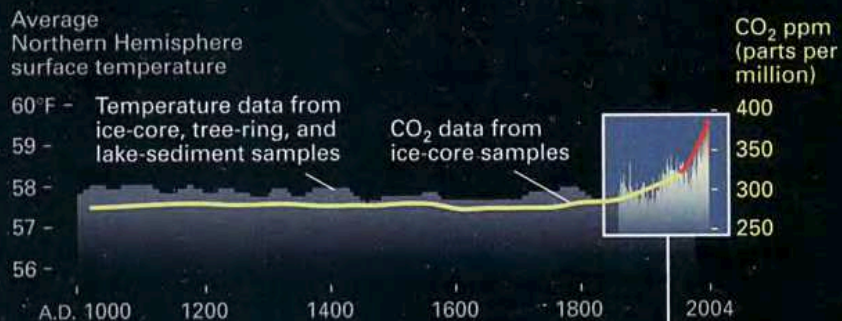
Temperature rising

Temperature and CO₂ records >>>>>>

■ Warming trends

The concentration of carbon dioxide in the atmosphere helps determine Earth's surface temperature. Both CO₂ and temperature have risen sharply since 1950.

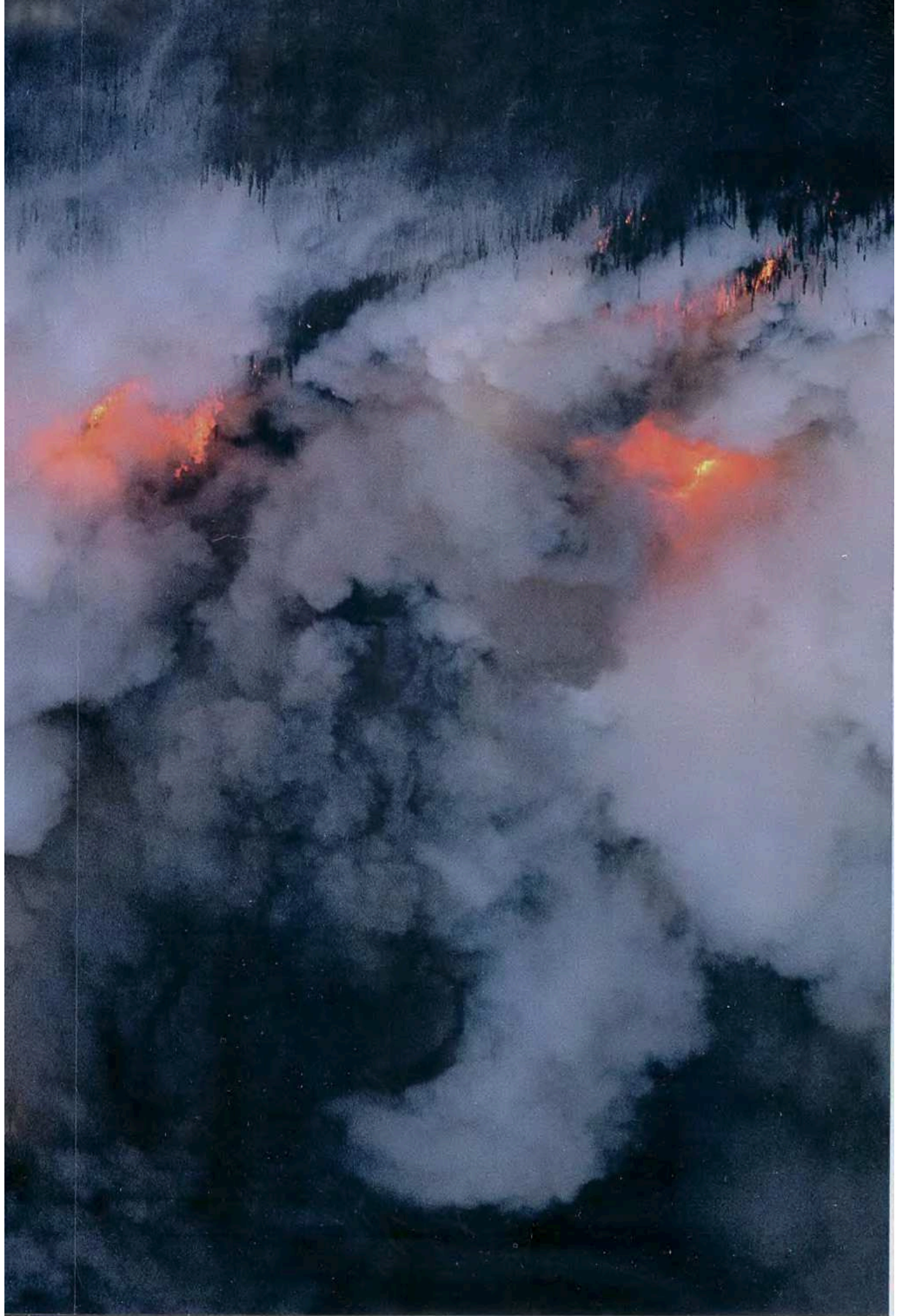
■ Over the past 140 years, forest clearing and fossil-fuel burning have pushed up the atmosphere's CO₂ level by nearly 100 parts per million. The average surface temperature of the Northern Hemisphere has mirrored the rise in CO₂. The 1990s was the warmest decade since the mid-1800s, and 1998 the warmest year.



One Degree of Change

A big difference Climate fluctuates naturally between warm and cool periods. But the 20th century has seen the greatest warming in at least a thousand years, and natural forces

can't account for it all. The rise of CO₂ and other heat-trapping gases in the atmosphere has contributed; both greenhouse gases and temperature are expected to continue rising.



A dramatic night sky with dark, swirling clouds. In the foreground, there is a body of water reflecting the bright orange and yellow light from below, possibly a fire or a volcanic eruption. The overall scene is dark and atmospheric.

Alaska Feelin'g



the Heat

Thick smoke towers over a forest near Fairbanks (left), one more sign that Alaska is getting hotter. In three decades the average temperature rose 4.16°F in the northern city of Barrow. The capital, Juneau, saw a 3.54° increase, and Anchorage, the state's most populous city, is 2.26° warmer. Northern coniferous forests, which become fire prone in hot weather, could be hit hard. Computer models predict that CO₂-induced warming could eventually raise the incidence



BETWEEN KAKTOVIC AND DEADHORSE, ALASKA

of fires by more than half.

Climate warming hits hard in cold regions partly because of albedo feedback. Snow and ice have a high albedo—that is, they reflect a lot of solar energy. But as heat melts snow and ice, darker, less reflective land or water is exposed (above). More heat is absorbed, giving rise to further melting and warming.

NORTH OF FAIRBANKS, ALASKA



DENALI NATIONAL PARK AND PRESERVE, ALASKA



OUTSIDE FAIRBANKS, ALASKA

Alaska's spectacular glaciers—among them Buckskin Glacier in Denali National Park and Preserve (top)—are disappearing. An estimated 23 cubic miles of water now runs off each year, the largest glacial contribution to sea-level rise on Earth. The heat is also melting permafrost that supports roads, buildings, and other infrastructure across most of the state. It's a bumpy ride on a bike path (above right) near Fairbanks, where once frozen soil has softened and chunks of

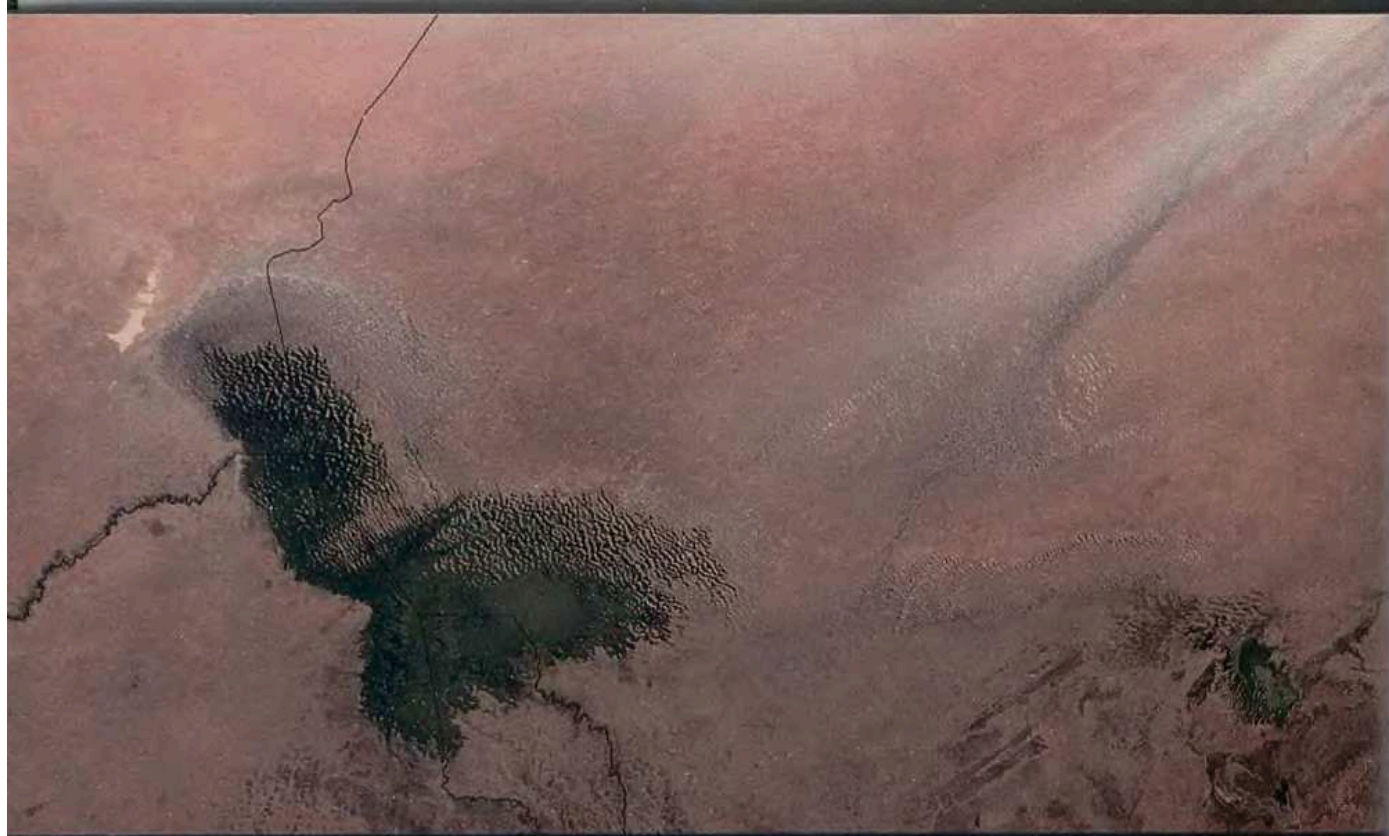


FAIRBANKS, ALASKA

underground ice have melted. The result is sharp dips and rises in what once was level ground. Even trees are susceptible to softening ground, leading to the phenomenon of the "drunken" forest (above left). In Shishmaref (below) waves undermine bluffs softened by permafrost melt. The early retreat of sea ice each year—in addition to making it harder for villagers to locate prey during traditional spring hunts—magnifies sea swells, causing further erosion.

SHISHMAREF, ALASKA





THE SAHEL, AFRICA



CHAD

Great Shrinking Lake

Seemingly endless drought in Africa's Sahel grassland has withered Lake Chad—once among the continent's largest lakes. In the past, water covered much of the dark area visible in a recent satellite image (top). The lake has shrunk to about 10 percent of its early 1960s extent, with seasonal wetlands replacing open water. The shallow lake responds rapidly to changes in precipitation, and even a small change in global climate can have a large impact on those who rely on the lake for fish and cropland irrigation.

(Continued from page 19) year, and the state is lobbying for federal money to help replace the upstream sediments that are the delta's lifeblood.

Local projects like that might not do much good in the very long run, though, depending on the course of change elsewhere on the planet. Part of Antarctica's Larsen Ice Shelf broke apart in early 2002. Although floating ice does not change sea level when it melts (any more than a glass of water will overflow when the ice cubes in it melt), scientists became concerned that the collapse could foreshadow the breakup of other ice shelves in Antarctica and allow increased glacial discharge into the sea from ice sheets on the continent. If the West Antarctic ice sheet were to break up, which scientists consider very unlikely this century, it alone contains enough ice to raise sea level by nearly 20 feet.

Even without such a major event, the IPCC projected in its 2001 report that sea level will rise anywhere between 4 and 35 inches by the end of the century. The high end of that projection—nearly three feet—would be “an unmitigated disaster,” according to Douglas.

Down on the bayou, all of those predictions make Windell Curole shudder. “We’re the guinea



Hottest years on record:

- 1. 1998
- 2. 2002
- 3. 2003
- 4. 2001
- 5. 1997

thermohaline circulation (“thermo” for heat and “haline” for salt). Warm, salty water flows from the tropical Atlantic north toward the Pole in surface currents like the Gulf Stream. This saline water loses heat to the air as it is carried to the far reaches of the North Atlantic. The coldness and high salinity together make the water more dense, and it sinks deep into the ocean. Surface water moves in to replace it. The deep, cold water flows into the South Atlantic, Indian, and Pacific Oceans, eventually mixing again with warm water and rising back to the surface.

Changes in water temperature and salinity, depending on how drastic they are, might have considerable effects on the ocean conveyor belt.

prevailing winds and differences in water density, which changes with the temperature and salinity of the seawater, ocean currents are critical in cooling, warming, and watering the planet's terrestrial surfaces—and in transferring heat from the Equator to the Poles.

The engine running the conveyor belt is the density-driven

The future breakdown of the thermohaline circulation remains a disturbing possibility.

pigs,” he says, surveying his aqueous world from the relatively lofty vantage point of a 12-foot-high earthen berm. “I don’t think anybody down here looks at the sea-level-rise problem and puts their heads in the sand.” That’s because soon there may not be much sand left.

Rising sea level is not the only change Earth's oceans are undergoing. The ten-year-long World Ocean Circulation Experiment, launched in 1990, has helped researchers to better understand what is now called the ocean conveyor belt (see page 66).

Oceans, in effect, mimic some functions of the human circulatory system. Just as arteries carry oxygenated blood from the heart to the extremities, and veins return blood to be replenished with oxygen, oceans provide life-sustaining circulation to the planet. Propelled mainly by

Ocean temperatures are rising in all ocean basins and at much deeper depths than previously thought, say scientists at the National Oceanic and Atmospheric Administration (NOAA). Arguably, the largest oceanic change ever measured in the era of modern instruments is in the declining salinity of the subpolar seas bordering the North Atlantic.

Robert Gagosian, president and director of the Woods Hole Oceanographic Institution, believes that oceans hold the key to potential dramatic shifts in the Earth's climate. He warns that too much change in ocean temperature and salinity could disrupt the North Atlantic thermohaline circulation enough to slow down or possibly halt the conveyor belt—causing drastic climate changes in time spans as short as a decade.

More than a hundred million people worldwide live within three feet of mean sea level.

The future breakdown of the thermohaline circulation remains a disturbing, if remote, possibility. But the link between changing atmospheric chemistry and the changing oceans is indisputable, says Nicholas Bates, a principal investigator for the Bermuda Atlantic Time-series Study station, which monitors the temperature, chemical composition, and salinity of deep-ocean water in the Sargasso Sea southeast of the Bermuda Triangle.

Oceans are important sinks, or absorption centers, for carbon dioxide, and take up about a third of human-generated CO₂. Data from the Bermuda monitoring programs show that CO₂ levels at the ocean surface are rising at about the same rate as atmospheric CO₂. But it is in the deeper levels where Bates has observed even greater change. In the waters between 250 and 450 meters (820 and 1,476 feet) deep, CO₂ levels are rising at nearly twice the rate as in the surface waters. "It's not a belief system; it's an observable scientific fact," Bates says. "And it shouldn't be doing that unless something fundamental has changed in this part of the ocean."

While scientists like Bates monitor changes in the oceans, others evaluate CO₂ levels in the atmosphere. In Vestmannaeyjar, Iceland, a lighthouse attendant opens a large silver suitcase that looks like something out of a James Bond movie, telescopes out an attached 15-foot rod, and flips a switch, activating a computer that controls several motors, valves, and stopcocks. Two two-and-a-half-liter flasks in the suitcase fill with ambient air. In North Africa, an Algerian monk at Assekrem does the same. Around the world, collectors like these are monitoring the cocoon of gases that compose our atmosphere and permit life as we know it to persist.

When the weekly collection is done, all the flasks are sent to Boulder, Colorado. There, Pieter Tans, a Dutch-born atmospheric scientist with NOAA's Climate Monitoring and Diagnostics Laboratory, oversees a slew of sensitive instruments that test the air in the flasks

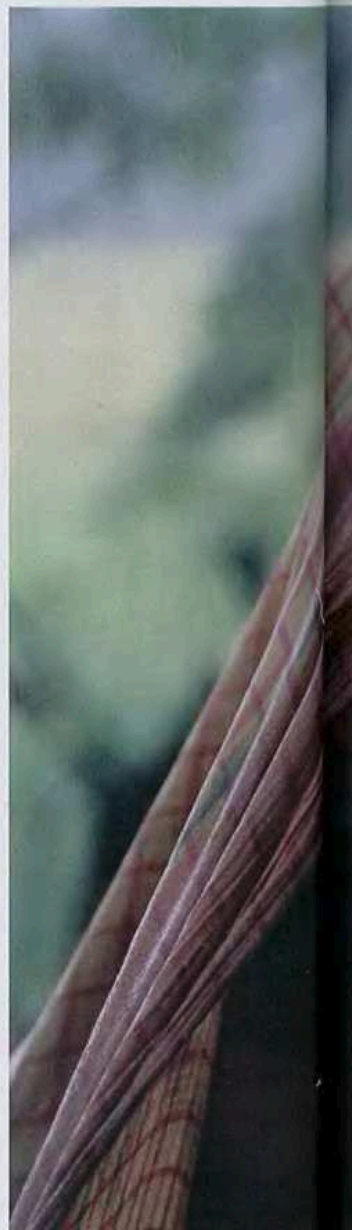
for its chemical composition. In this way Tans helps assess the state of the world's atmosphere.

By all accounts it has changed significantly in the past 150 years.

Walking through the various labs filled with cylinders of standardized gas mixtures, absolute manometers, and gas chromatographs, Tans offers up a short history of atmospheric monitoring. In the late 1950s a researcher named Charles Keeling began measuring CO₂ in the atmosphere above Hawaii's 13,679-foot Mauna Loa. The first thing that caught Keeling's eye was how CO₂

Soggy Future

Young Bangladeshis improvise shelter in the face of a downpour. The annual monsoon rains that sweep into southern and eastern Asia on the heels of the dry season may increase in intensity as a result of climate warming. Rising ocean temperatures could increase the incidence of cholera, and more rain could lead to crop reductions and increased malnutrition.



level rose and fell seasonally. That made sense since, during spring and summer, plants take in CO_2 during photosynthesis and produce oxygen in the atmosphere. In the fall and winter, when plants decay, they release greater quantities of CO_2 through respiration and decay. Keeling's vacillating seasonal curve became famous as a visual representation of the Earth "breathing."

Something else about the way the Earth was breathing attracted Keeling's attention. He watched as CO_2 level not only fluctuated seasonally, but also rose year after year. Carbon dioxide level has climbed from about 315 parts per million (ppm) from Keeling's first readings in 1958 to more than 375 ppm today. A primary source for this rise is indisputable: humans' prodigious burning of carbon-laden fossil fuels for their factories, homes, and cars.

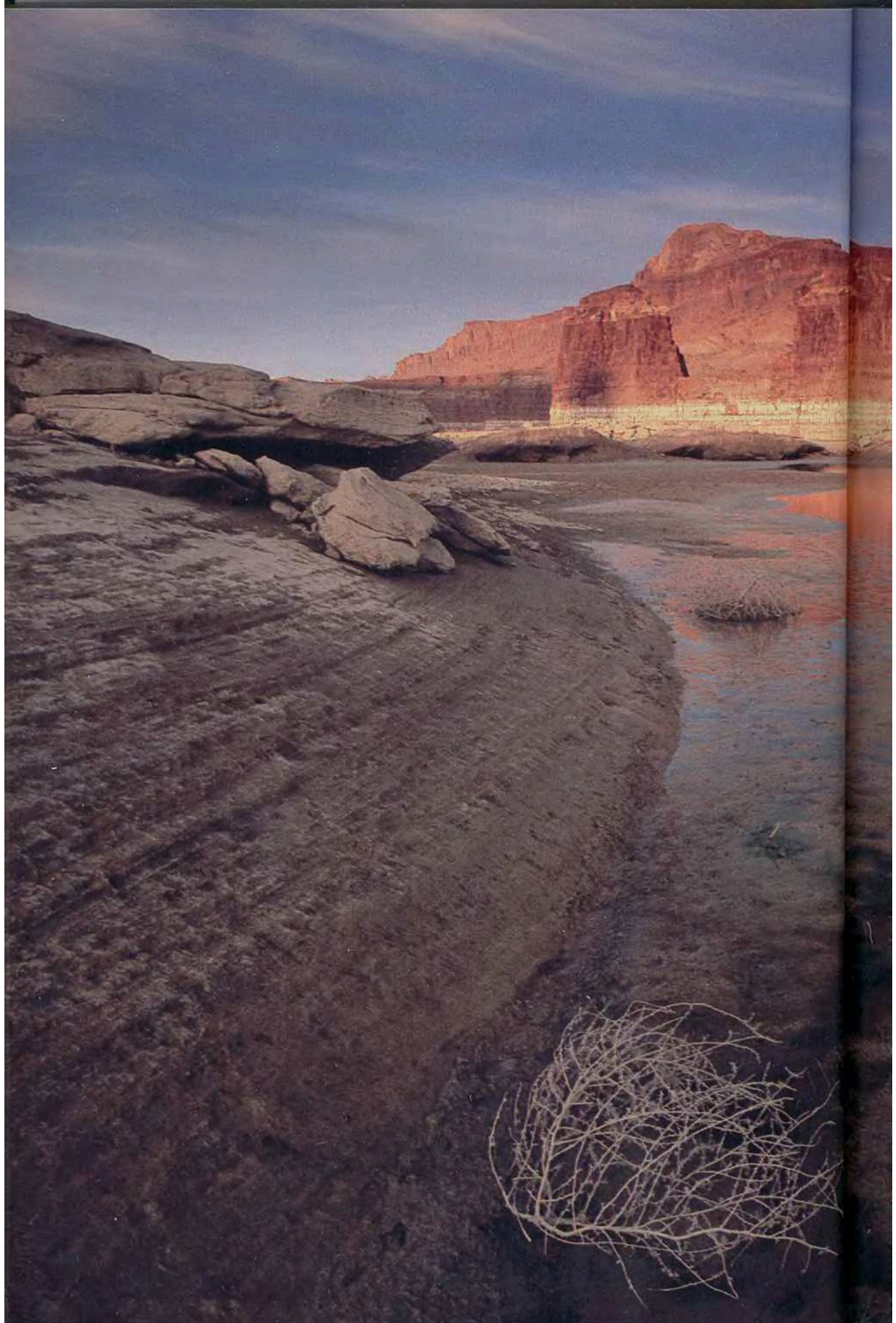
Tans shows me a graph depicting levels of three key greenhouse gases— CO_2 , methane, and


nitrous oxide—from the year 1000 to the present. The three gases together help keep Earth, which would otherwise be an inhospitably cold orbiting rock, temperate by orchestrating an intricate dance between the radiation of heat from Earth back to space (cooling the planet) and the absorption of radiation in the atmosphere (trapping it near the surface and thus warming the planet).

Tans and most other scientists believe that greenhouse gases are at the root of our changing climate. "These gases are a climate-change driver," says Tans, poking his graph definitively with his index finger. The three lines on the graph follow almost identical patterns: basically flat until the mid-1800s, then all three move upward in a trend that turns even more sharply upward after 1950. "This is what we did," says Tans, pointing to the parallel spikes. "We have very significantly changed the atmospheric concentration of these gases. We know their radiative properties," he says.

BANGLADESH







Drying Up in the Desert

Dry years since 1999 have drained Lake Powell to well below its high-water mark, visible on the sandstone bluffs of Glen Canyon. This Colorado River reservoir, which supplies hydroelectricity and water to millions living in the southwestern U.S., stands less than half full while the drought gripping the region drags into its fifth year. If droughts increase in severity as warming progresses—and some scientists predict they will—drastic water shortages could arise in heavily populated deserts.



SIERRA NEVADA, CALIFORNIA

Seasons Shift

As warmer temperatures creep up the slopes of California's Sierra Nevada, snowpack melts earlier, leaving some mountain streams (above) dry by summer. Downstream, the Sacramento River gets 12 percent less spring and summer snowmelt than it did a century ago, sparking worry in California about looming water deficits. In Madison, Wisconsin (below), winter is milder than in years past. Researchers monitoring ice on Lake Mendota find that ice cover on the lake averages about 40 fewer days now than it did 150 years ago. Says University of Wisconsin researcher John Magnuson, "Wisconsin is losing winter as we knew it."

MADISON, WISCONSIN



"It is inconceivable to me that the increase would not have a significant effect on climate."

Exactly how large that effect might be on the planet's health and respiratory system will continue to be a subject of great scientific and political debate—especially if the lines on the graph continue their upward trajectory.

Eugene Brower, an Inupiat Eskimo and president of the Barrow Whaling Captains' Association, doesn't need fancy parts-per-million measurements of CO₂ concentrations or long-term sea-level gauges to tell him that his world is changing.

"It's happening as we speak," the 56-year-old Brower says as we drive around his home in Barrow, Alaska—the United States' northernmost city—on a late August day. In his fire chief's truck, Brower takes me to his family's traditional ice cellars, painstakingly dug into the permafrost, and points out how his stores of muktuk—whale skin and blubber—recently began spoiling in the fall because melting water drips down to his food stores. Our next stop is the old Bureau

"It's not a belief system; it's an observable scientific fact."

of Indian Affairs school building. The once impenetrable permafrost that kept the foundation solid has bucked and heaved so much that walking through the school is almost like walking down the halls of an amusement park fun house. We head to the eroding beach and gaze out over open water. "Normally by now the ice would be coming in," Brower says, scrunching up his eyes and scanning the blue horizon.

We continue our tour. Barrow looks like a coastal community under siege. The ramshackle conglomeration of weather-beaten houses along the seaside gravel road stands protected from fall storm surges by miles-long berms of gravel and mud that block views of migrating gray whales. Yellow bulldozers and graders patrol the coast like sentries.

The Inupiat language has words that describe



Average temperature increase on the West Antarctic Peninsula since 1950:

■ winter: 8.8°F

■ annual: 4.5°F

bearded seals, walruses, and bowhead whales.

There are no words, though, to describe how much, and how fast, the ice is changing. Researchers long ago predicted that the most visible impacts from a globally warmer world would occur first at high latitudes: rising air and sea temperatures, earlier snowmelt, later ice freeze-up, reductions in sea ice, thawing permafrost, more erosion, increases in storm intensity. Now all those impacts have been documented in Alaska. "The changes observed here provide an early warning system for the rest of the planet," says Amanda Lynch, an Australian

researcher who is the principal investigator on a project that works with Barrow's residents to help them incorporate scientific data into management decisions for the city's threatened infrastructure.

Before leaving the Arctic, I drive to Point Barrow alone. There, at the tip of Alaska, roughshod hunting shacks dot the spit of land that marks the dividing line between the Chukchi and Beaufort Seas. Next to

one shack someone has planted three eight-foot sticks of white driftwood in the sand, then crisscrossed their tops with whale baleen, a horny substance that whales of the same name use to filter life-sustaining plankton out of seawater. The baleen, curiously, looks like palm fronds.

So there, on the North Slope of Alaska, stand three makeshift palm trees. Perhaps they are no more than an elaborate Inupiat joke, but these Arctic palms seem an enigmatic metaphor for the Earth's future. □

MELTDOWN What's happening to Earth's climate, and what are the implications for our future? Share your thoughts in our forum. Then explore the best the Web has to offer on global climate change with a listing of related websites and resources from our Research Division at nationalgeographic.com/magazine/0409.



ECO SIGNS

No Room to Run

Bleached coral, mistimed migrations, and dead forests count among the many complex effects of a warming global climate.

The Fleischmann's glass frog is barely hanging on in a tract of Costa Rican forest where, in the late 1980s, its numbers plunged inexplicably. More than half of that region's frog species also declined or vanished. As Earth's temperatures rise, scientists are exploring climate's role in a worldwide amphibian decline.







On the Rocks

Hunched against the elements along the Antarctic Peninsula, ecologist Bill Fraser counts Adélie penguins amid rocky nests red with guano. This colony dwindled from 320 breeding pairs to 54 between 1990 and 2004. Average winter temperatures here have increased nearly 9°F over five decades, and sea ice has retreated by a fifth since the mid-1970s, depriving Adélies of an important feeding platform from which they hunt krill. "The Adélies are the canaries in the coal mine of climate change in the Antarctic," says Fraser.



BY FEN MONTAIGNE

PHOTOGRAPHS BY PETER ESSICK

Biscoe Island is a small outcropping of rock and ice lost amid the epic landscape of the western Antarctic Peninsula. Looming above the island is the Marr Ice Piedmont, a massive glacier cleaved by 9,000-foot Mount Français. To the east, a few miles away, the sheer, jagged peaks of the peninsular chain—a checkerboard of black granite and broad glacial fields—plunge into the ocean. The blue waters of the Bellingshausen Sea are studded with icebergs and streaked



with sea ice. On a clear summer day the entire landscape—water, ice, rock—sparkles.

Ecologist Bill Fraser has been coming to the Antarctic Peninsula, an 800-mile finger of land that pokes upward toward South America, for 23 of the past 30 years. He can attest that the only thing that remains unchanged is the magnificent vista. In this corner of Antarctica, the land, the sea, and the creatures that inhabit them are all in flux as a result of some of the most rapid warming on Earth: Average winter temperatures have risen nearly 9°F in the past half century.

The most noticeable change has been the retreat of the Marr glacier, but most unsettling to Fraser—who came to Antarctica for adventure, solitude, and a Ph.D. on polar



Uphill Climb
Daniela Hohenwallner of the Global Observation Research Initiative in Alpine Environments (GLORIA) takes samples of mosses above 10,000 feet on Schrankogel, a peak in Austria. Rapid warming in high mountains may be forcing alpine flowers like *Helianthemum alpestre* (above) to compete with taller plants inching up from below. GLORIA has set up more than a hundred sites globally to document this upward shift.

AUSTRIAN ALPS (LEFT);
SWISS ALPS (ABOVE)

birds—has been the effect of the warming on Adélie penguins, his life's work. One day in January, at the height of the Antarctic summer, Fraser and I hiked to a promontory on Biscoe to census a nearby Adélie colony, a patch of pebble nests stained brick red with guano. Adélies commuted to and from the ocean in single file, transporting shrimplike krill to feed hundreds of downy, peeping chicks on shore.

Twenty years ago Biscoe was home to 2,800 breeding pairs of Adélies, one of only two ice-dependent polar penguin species (the other is the emperor) in Antarctica. Today the number of Adélie breeding pairs on Biscoe has dropped to about a thousand, mirroring a 66 percent Adélie decline on nearby islands, where numbers have plummeted in 30 years from 32,000 breeding pairs to 11,000. As Fraser's work has documented, the disappearing Adélies are being replaced by gentoo penguins, a subantarctic species that has begun migrating toward the Pole from more temperate climes, such as the Falkland Islands. A dozen breeding pairs of gentoos arrived on Biscoe in the early 1990s. Since then, their numbers have increased to 660 pairs.

Surveying Biscoe's western ridgeline, where gentoo numbers had risen by about a hundred since the last breeding season, Fraser looked like a person watching his block mutate into a slum.

"Man, oh, man, this is absolutely unbelievable," said Fraser, who works out of Palmer Station, a U.S. research base. "This whole area used to be Adélie colonies. Now the gentoos are using the same nesting sites. I think Biscoe will soon be Adélie free. These birds are doomed."

Just behind us, the Marr Ice Piedmont calved with a thunderous rumble, sending a wall of blue ice cascading into the ocean. This continual booming, I was beginning to understand, was the soundtrack accompanying the disappearance of Bill Fraser's Adélies.

"A century ago this was basically a polar environment," he said. "The area embodied Antarctica. Now we have this subantarctic system impinging. I've watched the confrontation over the past 30 years, and the polar system has really disintegrated at Palmer. I'm in awe that it has taken such a short time to happen. Lesson number one for me has been the realization that ecology and ecosystems can change"—he snapped his fingers—"like that. In geologic time it's a nanosecond."



"Ecology and ecosystems can change—like that. In geologic time it's a nanosecond."

The western Antarctic Peninsula has warmed so drastically because of a combination of rising global temperatures and regional shifts in ocean and air currents. Worldwide, temperatures have warmed far more slowly—an average of 1°F over the past century—yet even that relatively small change is rippling through the natural world. Fraser's painstaking studies on the Antarctic Peninsula provide clues to how rising temperatures can profoundly affect ecosystems all over the planet, where animals, plants, and insects are already

adapting to moderate climate change by shifting their ranges, advancing migration dates, and altering times of mating and flowering.

A study of 35 nonmigratory butterfly species in Europe found that in recent decades about two-thirds have expanded their ranges northward by 20 to 150 miles. Many plants in Europe flower about a week earlier than they did 50 years ago and shed their leaves in the fall five days later. British birds breed an average of nine days earlier than in the mid-20th century, and frogs mate up to seven weeks sooner. Tree



swallows in North America migrate north in spring 12 days earlier than they did a quarter century ago. Red foxes in Canada are shifting their ranges hundreds of miles toward the Pole, moving into the territories of Arctic foxes. Alpine plants are edging uphill and beginning to overrun rare species near mountain summits.

Although the Earth's climate has always been subject to natural variation, with shifts between cold and warm, the current warming trend has ecologists worried for several reasons. This is the first instance in which humans appear to be accelerating the change, and warming could take place so quickly that species will not have the time to adapt and avoid extinction. And since different species react to climate change in different ways, the natural cycles of interdependent creatures—such as birds and the insects they feed on—may fall out of sync, causing population declines.

Pests and Pathogens

Four million acres of Alaska spruce, like these Sitkas by the Kachemak Bay, stand dead, victims of the spruce bark beetle. "We went into overdrive, climate-wise," says ecologist Ed Berg of the warmer summers since 1987. The warmth has boosted the numbers of mature beetles.

Monte Deatrick of metro Denver's Tri-County Health Department (right) tests a chicken for West Nile virus, which exploded in Colorado in 2003. Some suspect that a six-year drought concentrated migratory birds and virus-carrying mosquitoes at water sources, where the disease spread fast.

For now, as much of the world warms, animals and plants can try to beat the heat by retreating to higher latitudes and elevations. But such escape routes have limits, some of them imposed by humans. Unlike in past millennia, flora and fauna must cope in a world that is not only warming but is also home to 6.3 billion people.

"During past major climate changes, there wasn't a lot of human disturbance," says Camille Parmesan, an ecologist at the University of Texas at Austin. "Species could shift around. Now if they try to shift, they may be driven into a cornfield—or Chicago."

Parmesan conducted a study highlighting the pressure that species face when squeezed between a warming world and habitat destruction. In a 300-mile swath of territory between northern Mexico and southern California, the Edith's checkerspot butterfly has become extinct in 80 percent of its historical range. The



KENAI PENINSULA, ALASKA (LEFT); DENVER, COLORADO (ABOVE)

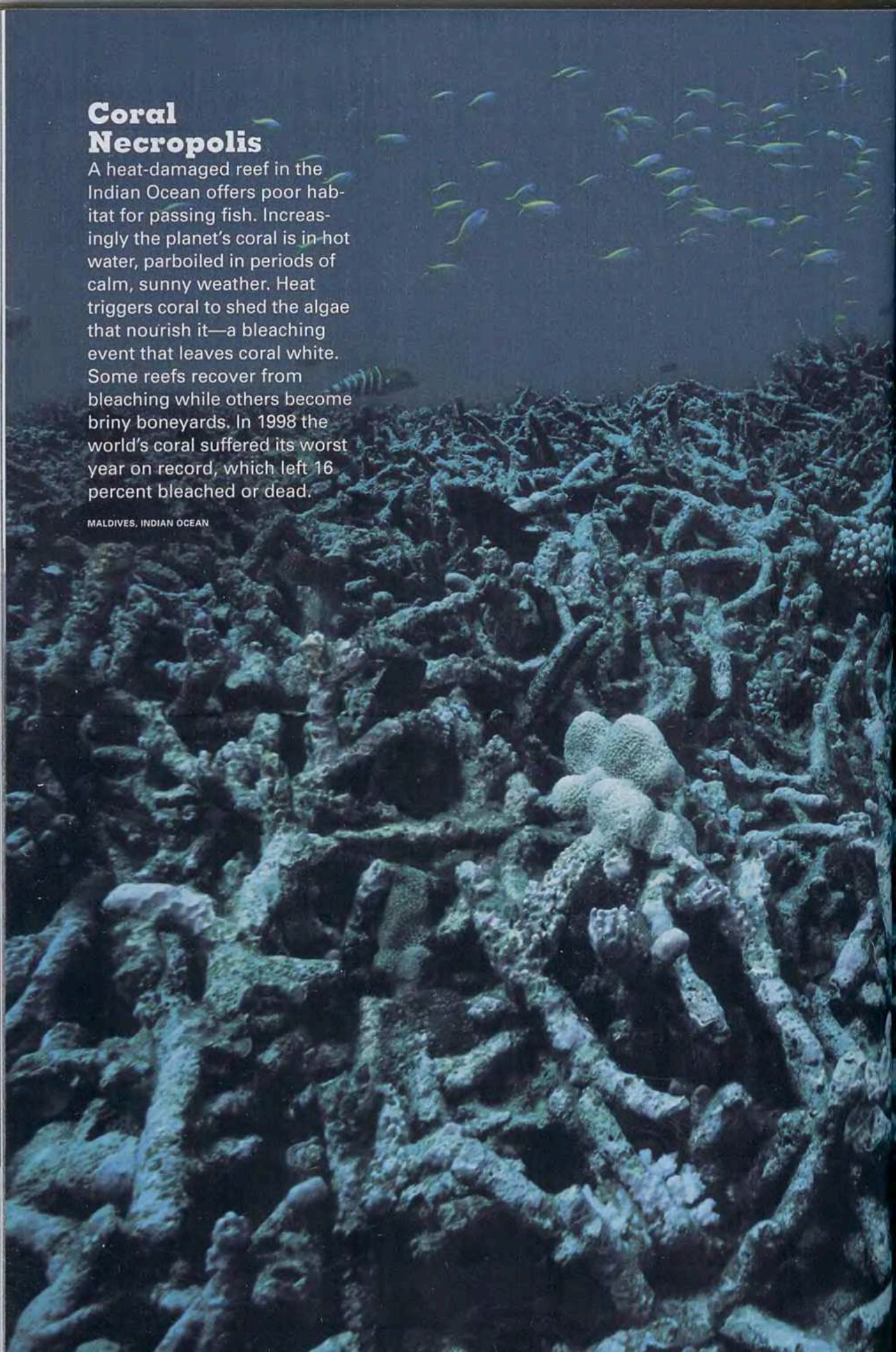
major cause, Parmesan showed, has been rising temperatures, which have led to the early desiccation of host snapdragon plants, depriving the butterfly larvae of crucial nutrition. Most of the southern populations, in otherwise prime Mexican habitat, are now extinct. And to the north, San Diego sprawl is gobbling up cooler sites that could support healthy colonies of the Edith's checkerspot.

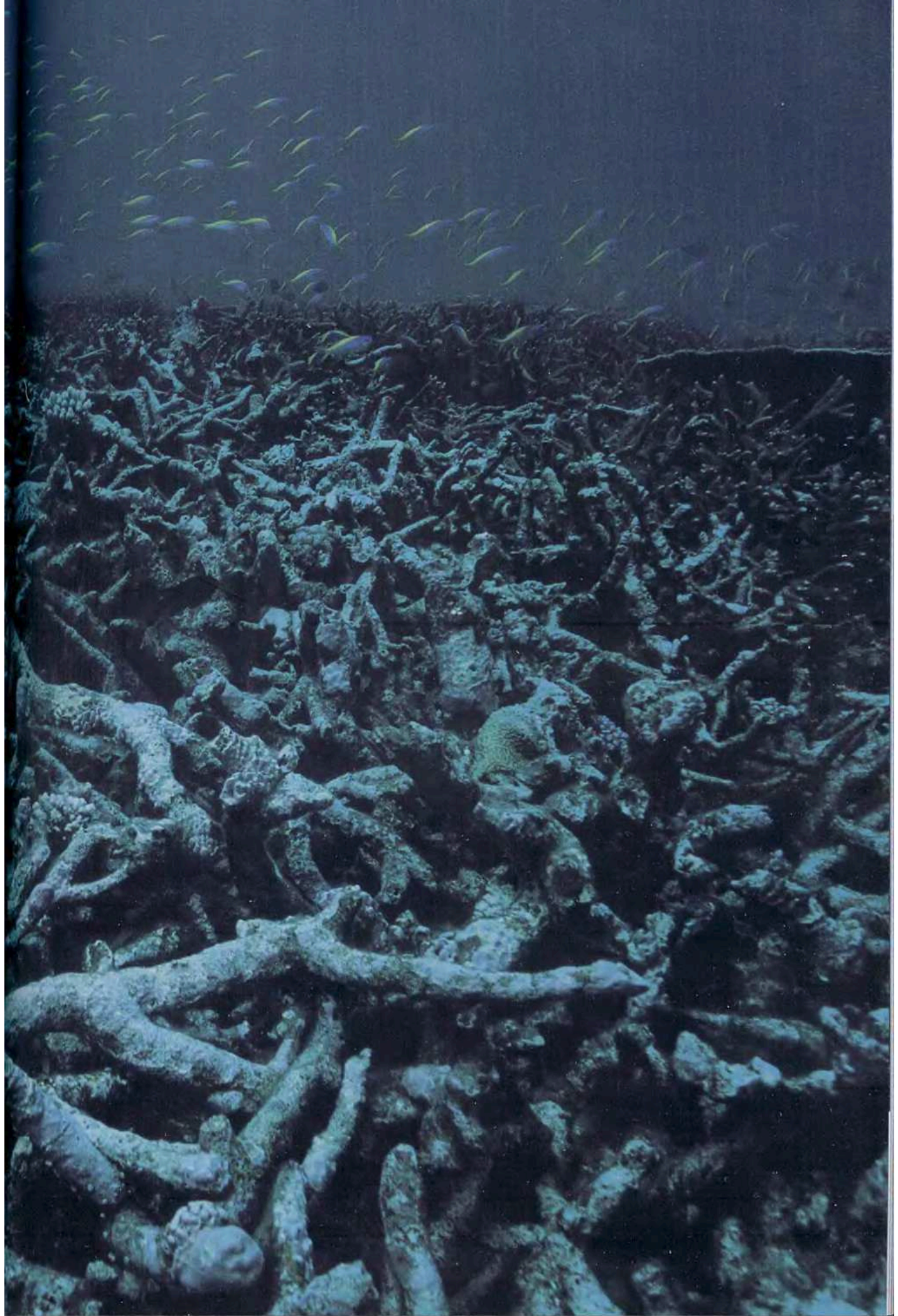
At some point, as temperatures continue to rise, species will have no more room to run. Such is Bill Fraser's worry about the Adélies. Today only the 300,000 pairs that live on the Antarctic Peninsula seem to be at risk from climate warming. Another 2.2 million pairs are doing well elsewhere in Antarctica, in the far colder, more southerly *(Continued on page 46)*

Coral Necropolis

A heat-damaged reef in the Indian Ocean offers poor habitat for passing fish. Increasingly the planet's coral is in hot water, parboiled in periods of calm, sunny weather. Heat triggers coral to shed the algae that nourish it—a bleaching event that leaves coral white. Some reefs recover from bleaching while others become briny boneyards. In 1998 the world's coral suffered its worst year on record, which left 16 percent bleached or dead.

MALDIVES, INDIAN OCEAN





Shorter winters

Lake-ice freeze and breakup dates >>>>>

■ **Less ice**

Many lakes are freezing later in the fall and thawing earlier in the spring than in the 19th century.

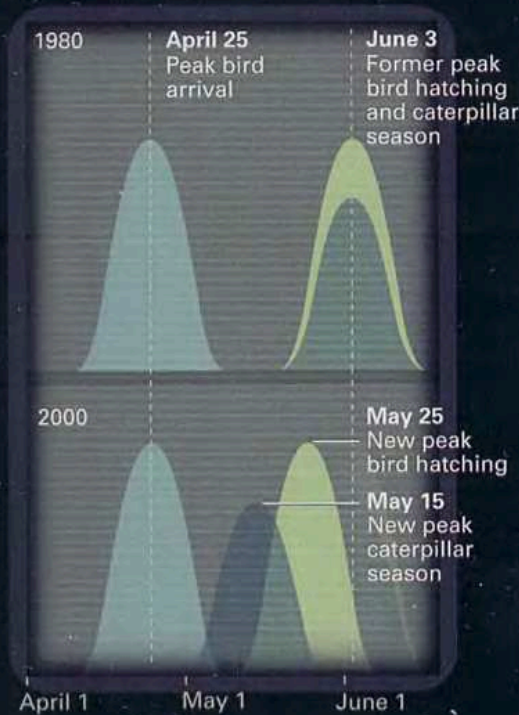


Nature changing its habits

Cycles out of sync >>>>>>>>>>>

■ **Off schedule**

Flycatcher birds that migrate from Africa to the Netherlands to nest still arrive at the same time now as they did two decades ago. But because of warming, moth caterpillars on which nestlings feed emerge two weeks earlier than before. The birds' peak hatching date has shifted too, but not enough. Nestlings now miss peak caterpillar hatching and may go hungry.



■ **Plants shift**

Warming in the mountains of southern Switzerland (thus fewer days of frost) has forced some plants upslope and allowed exotic plant species to invade.



■ ■ ■ A Shift in Seasons

Life out of kilter As temperatures rise, seasonal cues are altered, and life is shifting in space and time. Habitats are changing along with the timing of annual processes like flowering, leaf coverage, migration, and

birth. Species that depend on each other—plants and the insects that pollinate them, for example—don't always adapt to changes at the same time. In some cases they are slipping dangerously out of sync.

(Continued from page 41) parts of their range. But how many more decades, Fraser wonders, will that last?

Standing on the fringes of an Adélie colony on Humble Island, Fraser surveyed more than a hundred nine-pound, knee-high spheres of solid muscle. Packed tightly together, the penguins pecked at neighbors that infringed upon their territory. An incessant honking and trumpeting rose from the colony. Smearing with a gumbo of urine and guano, pear-shaped gray chicks hovered close to their nests, awaiting the arrival of a parent that would regurgitate several ounces of krill down their throats.

I remarked on the overpowering stench, but Fraser—tall and slender, dressed in a sun-bleached green parka, beige baseball cap, and black rain pants spattered white and red with

bird excrement—seemed to take no notice. “Smells like life,” he said.

Fraser was searching for a penguin on which to affix a satellite transmitter, a three-inch, waterproof device that would let him know where the Adélies were foraging. Crouching, he took a few steps into the colony, setting off a frantic chorus of alarm. He snatched a bird by the flipper and brought it, flailing and squawking, to the waiting lap of biologist Cindy Anderson, who taped the transmitter to its back.

The transmitter would tell Fraser and Anderson that the Adélies were feeding within ten miles, as there was an abundance of krill close to shore this year. Such foraging information is an important part of the ecological puzzle Fraser and his colleagues are piecing together about the Antarctic Peninsula. Sea ice is a nursery for krill, and krill are the key link in a food chain that supports penguins, whales, and many other

BUCK ISLAND, CARIBBEAN SEA



animals. If sea ice keeps retreating, then krill—and everything that eats them—could be in trouble.

Fraser first came to Antarctica in 1974 as a graduate student at the University of Minnesota. He was based at Palmer Station, on the west side of the peninsula. Palmer is accessible only by boat, and back then almost nothing was known about the wildlife there. So Fraser began censusing seals and seabirds, noting the dates of their arrival, hatching, and fledging. He gave scant thought to global warming, but the data he steadily compiled would eventually prove crucial to his future work on climate change.

"I fell in love with the sheer wildness that existed here," recalls Fraser, who is now president of the nonprofit Polar Oceans Research



Four species threatened by global warming in polar or mountain regions:

- polar bear
- gelada baboon
- pygmy possum
- monarch butterfly

side the wound and see her lungs. The Adélie hovered around her chicks, scarcely moving for a week while her mate foraged for food. Then, her wounds partly healed, she headed to sea and resumed feeding her offspring.

"Adélies are the toughest animals I've ever encountered," says Fraser. "They're 18 inches tall and they can't fly, but they can swim 3,500 miles in a winter migration. They thrive in what has to be the harshest environment on the planet."

Beginning in 1983, Fraser spent springs and summers at Palmer, and after seven years he began to unravel the mystery of the Adélies' decline around the region. In December 1990 Fraser stood on a rocky ridge that bisects Torgersen Island. He looked at the northern half of the island, which was largely snow free, and saw thousands of nesting Adélies. Then he looked to the south and saw Adélies struggling to nest in deep snow.

The western Antarctic Peninsula has received more snow in recent decades, a phenomenon linked, oddly enough, to rising temperatures: Less ice covering the ocean means greater evaporation of seawater, which at Palmer translates into increased snowfall. Around Palmer storms generally blow from the northeast. Snow piles up on the sheltered lee, or south, sides of ridges. And it is the Adélie colonies on the south sides of promontories that have been experiencing precipitous population drops.

"All of a sudden this lightbulb went on," recalls Fraser. The Adélies, hardwired to nest in the same place at the same time year after year, were trying to incubate eggs in snow or snowmelt, where they failed to hatch. As a result, the colonies were withering away. The Adélie population on Litchfield Island, where the colonies were all on the lee side of a ridge, has experienced a collapse in numbers from 884 breeding

Gender Gap

Biologist Zandy Hillis-Starr sheds light on endangered hawksbill sea turtles newly hatched in the Virgin Islands. Scientists have long known that hot weather during the middle third of incubation causes the turtles' eggs to yield more females. Now they have detected more females among sea turtles worldwide, with unknown long-term consequences for the species. Storms amplify the trend, shearing away trees that provide cooling shade to nests on beaches. "Severe weather events," says Hillis-Starr, "really knock the socks off in favor of the females."



At some point, as temperatures continue to rise, species will have no more room to run.

pairs in 1974 to 47 today. Fraser knew the Adélies had not migrated elsewhere, as his team had banded 20,000 penguins, only a few of which were found in other locations.

But Fraser also knew that Adélies were being affected by more than local conditions, for even colonies in relatively snow-free spots were shrinking. Larger forces were at work, and sea ice—vital to the Antarctic ecosystem—was at the heart of the matter. Adélies depend on sea ice as a feeding and resting platform. The gentoo penguins that are replacing them thrive in open water. Sea ice on the western Antarctic Peninsula has declined by about 20 percent, depriving the Adélies of important jumping-off points for rich winter feeding grounds.

Fraser continues to make important field observations. He discovered recently that Antarctic silverfish—once an important food for Adélies—have disappeared from the Palmer Station area and are now found only in colder waters farther south. He also has documented an invasion of fur seals, a subantarctic mammal, from areas such as South Georgia Island, 1,400 miles to the northeast. In 1974 Fraser counted six fur seals on the islands surrounding Palmer Station. Last summer he and his team saw 3,000.

In effect, over three decades, Fraser and his colleagues have recorded the retreat of an Antarctic ecosystem. In Fraser's words: "It has gone to hell."

At the top of the world, in the Arctic, climate change is occurring swiftly as well, and animals and birds appear to be feeling the effects. As temperatures have risen across the Arctic, permanent sea ice has declined by 9 percent per decade since 1978, when satellite monitoring of the ice cover began. In Hudson Bay the summer sea ice breakup now generally occurs two to three weeks earlier than it did during the mid-20th century. For animals that spend most of their year living and feeding on the ice—notably

polar bears and ringed seals—the continuing loss of sea ice could be disastrous.

Last September I joined Martyn Obbard, a wildlife research scientist with the Ontario Ministry of Natural Resources, on the shores of southern Hudson Bay. An estimated 1,000 polar bears inhabit this region at the southern edge of the species' range in North America. Obbard, accompanied by veterinarian and fellow biologist Marc Cattet, was in the final year of a four-year project to weigh, measure, and take physiological samples from roughly 300 bears.

Obbard would compare his measurements with those taken by biologists in the same region two decades ago. If polar bears are being forced to abandon the ice two to three weeks earlier than in the 1980s—departing at a time when they traditionally gorge on ringed seal



UTAH (ABOVE): EL ROSARIO PRESERVE, MICHOACÁN STATE, MEXICO (RIGHT)

Heights of Vulnerability

Freezing temperatures and more precipitation proved a lethal combination for millions of monarch butterflies in Mexico's mountains in early 2000. More such weather is projected. Cold-loving pikas in North America could face extinction if temperatures keep rising, driving the heat-sensitive mammals uphill to summits that effectively become shrinking islands of habitat.





Cloud Forests in Flux

MONTEVERDE, COSTA RICA (ALL)



Of the world's already diminished rain forest, less than 2.5 percent is considered cloud forest—a fragile environment blanketed by mist between 6,600 feet and 9,800 feet in tropical mountains. Mist is critical to the health of a *Pleurothallis* orchid (left), a tree-dwelling species from Costa Rica's Monteverde forest. Scientists have detected an increase in clouds in the forest (bottom), but the clouds are forming at higher altitudes. These warming-induced changes are forcing some species to move upslope. Biologist Debra Hamilton, who is studying the shifts, extracts an orange-billed nightingale thrush from a research net (below).



pups—then the loss of a crucial feeding period should, Obbard hypothesized, be taking a measurable toll on their health.

On a gray, windy day we lifted off from the village of Peawanuck in a five-seat helicopter, following the Winisk River north toward Hudson Bay. Flying over tundra occasionally broken by stands of pine and larch, we soon spotted polar bears along the shoreline, where they spend the summer months fasting as they wait for sea ice to form in the fall. Obbard saw a mother and cub a half mile ahead, and we descended. Leaning out of the helicopter, Obbard fired an anesthetic-filled dart into the mother. Within five minutes she was motionless on her side in the grass.

Landing nearby, we approached the bears. The nine-month-old cub straddled its mother's body, swinging its head from side to side. Biologist Lyle Walton worked his way to the rear and jabbed the cub in the neck with a syringe attached to a long pole. Soon the cub, too, was out, its head resting in the crook of its mother's arm. For the next two hours, the scientists took blood and fat samples and weighed the bears using a stretcher and pulley. The cub weighed 172 pounds and the mother 542 pounds. Both appeared healthy.

But while they may be healthy, they're not as hardy as the bears of two decades ago. Obbard has found that since the mid-1980s, the ratio of body mass to length among polar bears in southern Hudson Bay has dropped about 15 percent. In short, the bears are getting skinnier.

Polar bear biologist Ian Stirling has found similar body-mass declines among 1,200 bears in western Hudson Bay. Stirling, a researcher with the Canadian Wildlife Service, has also detected other trends indicating polar bears may not be getting enough food these days. Several decades ago in western Hudson Bay, triplet polar bear cubs were common. Now they're virtually nonexistent. Once, up to 40 percent of the cubs were weaned by 18 months, finding food for themselves. Today fewer than 5 percent of them are.

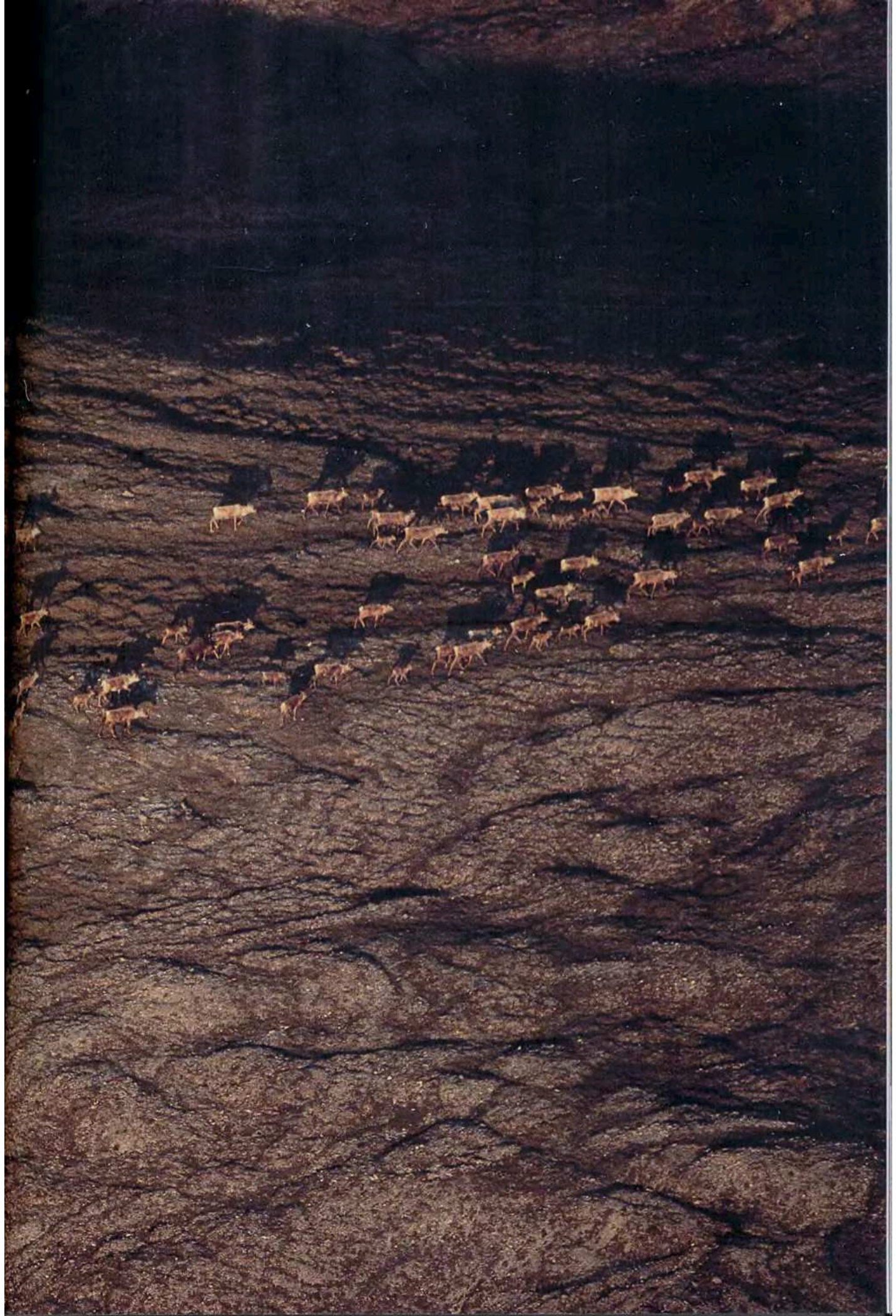
Stirling is convinced that the regression of sea ice is the culprit. And he fears that Hudson Bay's several thousand polar bears—part of an estimated worldwide population of 25,000—will vanish if, as climatologists have forecast, sea ice disappears from the bay by 2070.

Herd on Its Heels

Caribou from the Porcupine herd hoof it across northern Canada on their summer migration from birthing grounds in and around Alaska's Arctic National Wildlife Refuge. Their numbers declined from 178,000 in 1989 to 123,000 at last count in 2001. Scientists suspect that climate warming is a cause. The spring greening starts and ends earlier, and vegetation may die back before calves can gain enough weight to survive the winter.

YUKON TERRITORY, CANADA





The natural cycles of interdependent creatures may fall out of sync.

Obbard and Cattet say the link between retreating sea ice and declining bear body mass, though likely, has yet to be conclusively proved. The pair agrees with Stirling on a key issue: If temperatures keep climbing and sea ice continues to melt, the bears of Hudson Bay face a bleak future.

“No doubt if these trends continue for the next 50 years, Hudson Bay polar bears will never make a living,” says Cattet. “They’re toast. They’ll either have to learn to hunt caribou or head up to the high Arctic.”

TOOLIK LAKE, ALASKA

In late January, near the end of my stay at Palmer Station, Bill Fraser and I set out in a Zodiac boat to make the short trip to Torgersen Island. In the four weeks I’d been on the Antarctic Peninsula, I’d seen the Adélie chicks grow from fuzz balls to full-fledged seabirds weighing nearly as much as their parents. Most of the chicks had crèched, wandering away from their nests and hanging out in large packs, not unlike the students at any high school. The chicks hounded their parents continually, begging for food.



But Adélie adults have an intriguing way of dealing with annoying adolescents. Unable to keep feeding the chicks, the parents leave and don't come back. After a few days the chicks grow hungry and head to the sea in droves. At last, as their hunger grows by the day, they plunge in, flail around, and begin to pursue krill.

Though Torgersen Island has experienced a free fall in Adélie numbers—from 9,000 breeding pairs to 3,200—enough penguins still breed on the north side to remind Fraser of the abundance of the 1970s. Then, in the lingering summer evenings, Fraser would take in the sight of 30,000 adults and chicks squawking and feeding on the beaches.

"There was a constant stream of birds, two to five penguins wide, walking to the ocean," recalls Fraser. "It was like ants in the forest. Torgersen was an absolute mass of life. It manifested the incredible productivity of this ocean."

Greenhouse Effect

A forecast of Alaska's likely future grows 360 miles north of Fairbanks. Birch takes over from tundra in a greenhouse where nitrogen and phosphorus added to the soil mimic the effect of faster decomposition in a warmer climate. Temperatures inside average 6.3° F higher than outside. That's more warming than is predicted for the near future, concedes ecologist Gus Shaver, "but we're hitting the system with a hammer to see what direction it takes."



We walked to the snowy south side of the island, where the number of breeding pairs has fallen most drastically—from 1,200 to 99. In all directions lay fields of gray pebbles that Adélies had carried in their beaks to now abandoned nest sites. Once a colony dips below about 30 pairs, the scarcity of adults watching for danger makes eggs and chicks easy prey for the gull-like brown skua, and Fraser ticked off the damage at the south side's four most recent colonies: Colonies two and three abandoned, all of colony one's eggs and chicks, ten total, eaten by skuas this season, and 48 chicks still standing in colony four. He predicted that south Torgersen would soon be Adélie free.

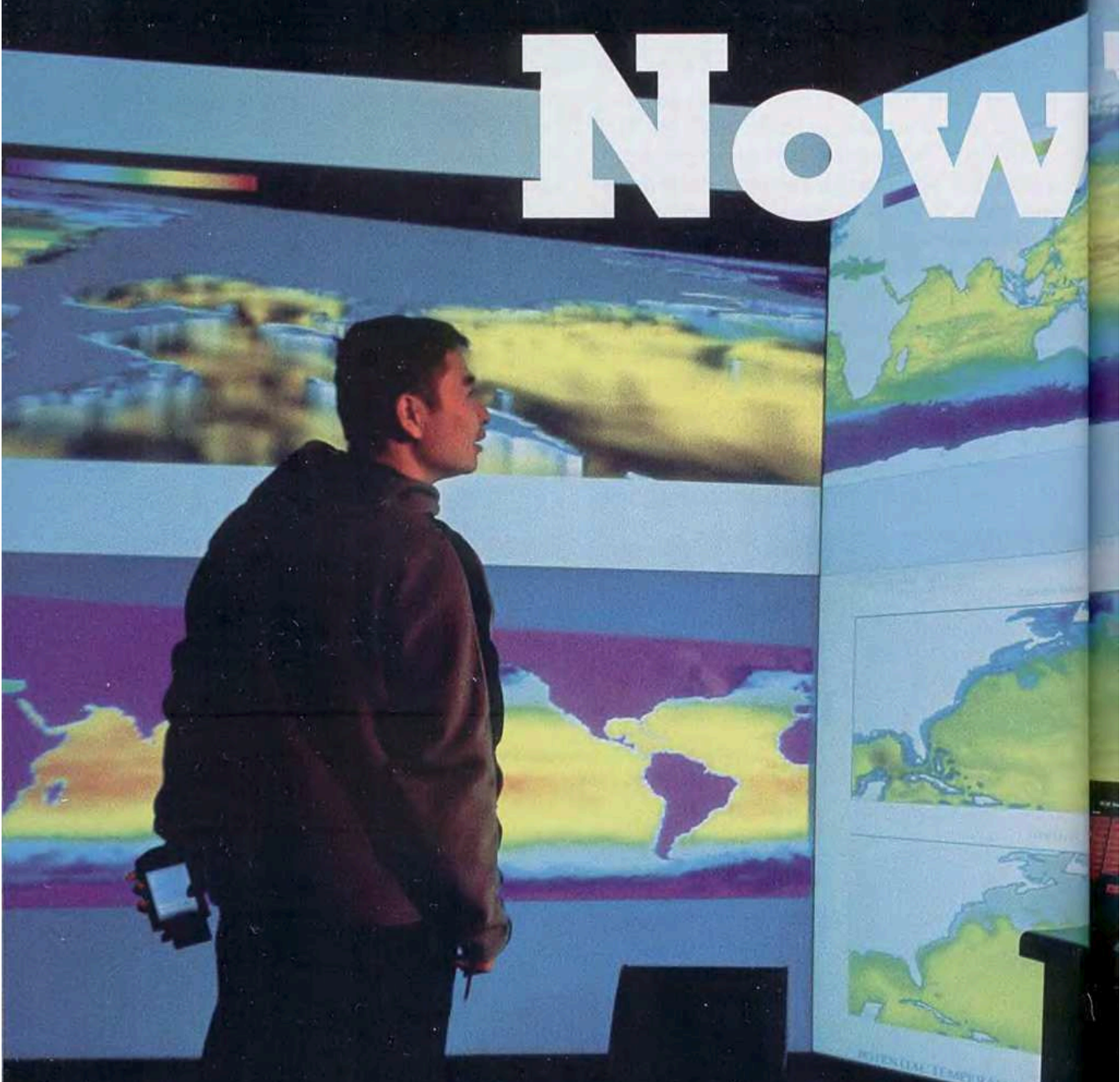
"It's pretty pathetic," he remarked. "I've seen it time and again, same scenario. You remember the colony filled with Adélies, and you watch it dwindle until you actually see the last few survivors."

"It's as though the life of this place is slowly being drained away. They're so tough, but everything seems to be working against them. If there's a human footprint attached to this [warming], and there probably is, here you have this unbelievably tough little animal, able to deal with anything, succumbing to the large-scale effects of our activities. And that's the one thing they can't deal with. That's what angers me about the whole picture, that these incredible animals have to take it in the neck because a bunch of humans can't get together to decide what to do about the planet."

Later, Fraser and his team returned to Torgersen Island to pump the stomachs of Adélies and see what they were eating. As the scientists worked, I turned around to watch scores of penguins marching to the sea. Clouds hovered low above the Marr glacier, and the evening breeze was light. Extending their flippers for balance, the Adélies walked across gray stones polished over centuries by the passage of their ancestors. The birds' steps were delicate, and the padding of their pink, webbed feet on the rocks made one of the loveliest sounds I've ever heard—a gentle clink, clink, clink, reminiscent of wind chimes. □

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What do you get when you compare hundreds of thousands of years of climate data from glaciers, caves, and coral reefs with climate projections modeled by the world's most powerful supercomputers? Factor in a heavy dose of greenhouse gases, and you get a harrowing forecast.

What?



Computer scientist Jason Sun views multiple screens to monitor the intricate interplay of warm and cold ocean currents—a prime driver of Earth's changing climate.

UNIVERSITY OF TEXAS, AUSTIN



SAN PEDRO VALLEY, ARIZONA

BY VIRGINIA MORELL
PHOTOGRAPHS BY PETER ESSICK

“One. Two. Three. Lift!” barks Cathy Whitlock, a fossil pollen expert and paleoclimatologist at the University of Oregon. She and the three of us—two of her students and I—tighten our grips on the cold metal tube of a lake-bed drilling rig and heave. “Again,” she commands. Slowly, inch by inch and groan by groan, the coring barrel that

Whitlock and her students had manhandled into the marshy shore of Little Lake, a blue jewel of water in Oregon’s central Coast Range, emerges from the mud.

“Once more,” orders Whitlock. We bend to the task and at last free the barrel from the muck. Whitlock has extracted a couple hundred similar cores from the deep sediments of this lake, but she beams like a kid getting her first bike as she slides her latest sample of old

mud, five centimeters thick and a meter long, out of the barrel.

“Oh, that’s a lovely core,” she says. To me it looks about as interesting as a Tootsie Roll. But to Whitlock’s trained eye even the chocolate hue of the mud holds a story. “That rich brown color tells you it’s full of organic matter—especially pollen,” she says, slicing the core in half lengthwise with her pocketknife. “You can’t see the pollen without a microscope, but it’s there.”



EVERGLADES, FLORIDA

And in that pollen lie clues to one of the greatest puzzles facing researchers like Whitlock: What has caused—and will cause again—the sudden climate changes that our Earth periodically undergoes? Not the 100,000-year fluctuations between a glaciated and a warmer Earth that have occurred for the past million years or so, but the more rapid shifts that scientists have recently identified when the Earth switched suddenly from frozen ice age to picnic-warm and back again. How often and how quickly have such dramatic changes happened? Perhaps most important, what do these past abrupt reversals tell us about the direction of Earth's climate today and in the future?

To answer such questions, scientists are busy unearthing signs of ancient climate in a surprising array of sources: glacial ice and moraines, stalagmites from caverns, tree rings and corals, dust and sand dunes, and the microscopic shells of organisms buried in deep-ocean sediments. Others, hoping to piece together the climate of the more recent past, turn to human records, using archaeological inscriptions, vintner and gardening diaries, and ship captains' logs. "We need both human

Wetlands Then and Now

A black line of decayed plants atop a white layer of carbonate and fossil shells (opposite) is all that's left of marshes that dominated the San Pedro Valley during the last ice age. The Everglades' vast mangrove forests (above) won't last as long. A dramatic rise in sea level—nine inches since 1930 in South Florida—could put the mangroves underwater this century.

and natural records," explains Ohio State University glaciologist Lonnie Thompson, who specializes in retrieving ice cores from the dwindling glaciers on tropical mountains. "We want to understand how the climate worked before and after people appeared. That's the only way we'll figure out what impact people have on climate, how much we're responsible for the way it's changing now."

Just how swiftly climate changes can occur is clear from Whitlock's study of her Little Lake cores. Those like the ones we drilled are stored at her university lab. Each meter of mud contains about 2,300 years of pollen grains from trees, grasses, and flowering plants. To find the



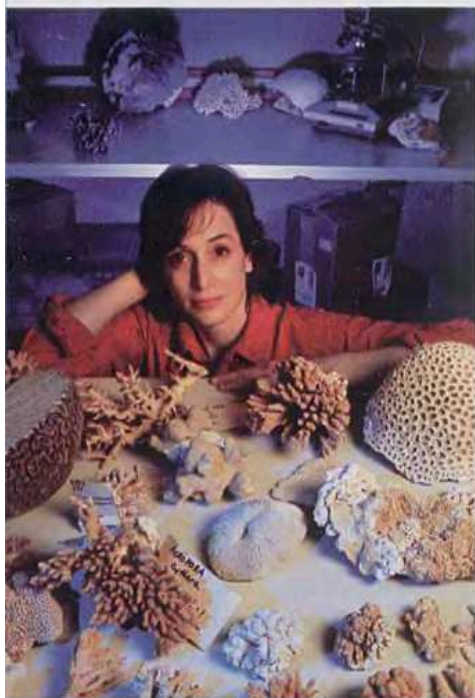
Cutting to the Core



Stalagmites provide a trove of past climate data for University of Iowa geologist Jeff Dorale (top), holding a sample from Crevice Cave in southeastern Missouri. By measuring isotopes of uranium, as well as mud embedded in the slow-growing stalagmites, Dorale and colleagues believe they can link El Niño events to flooding in the cave and higher rainfall over the past 10,000 years.

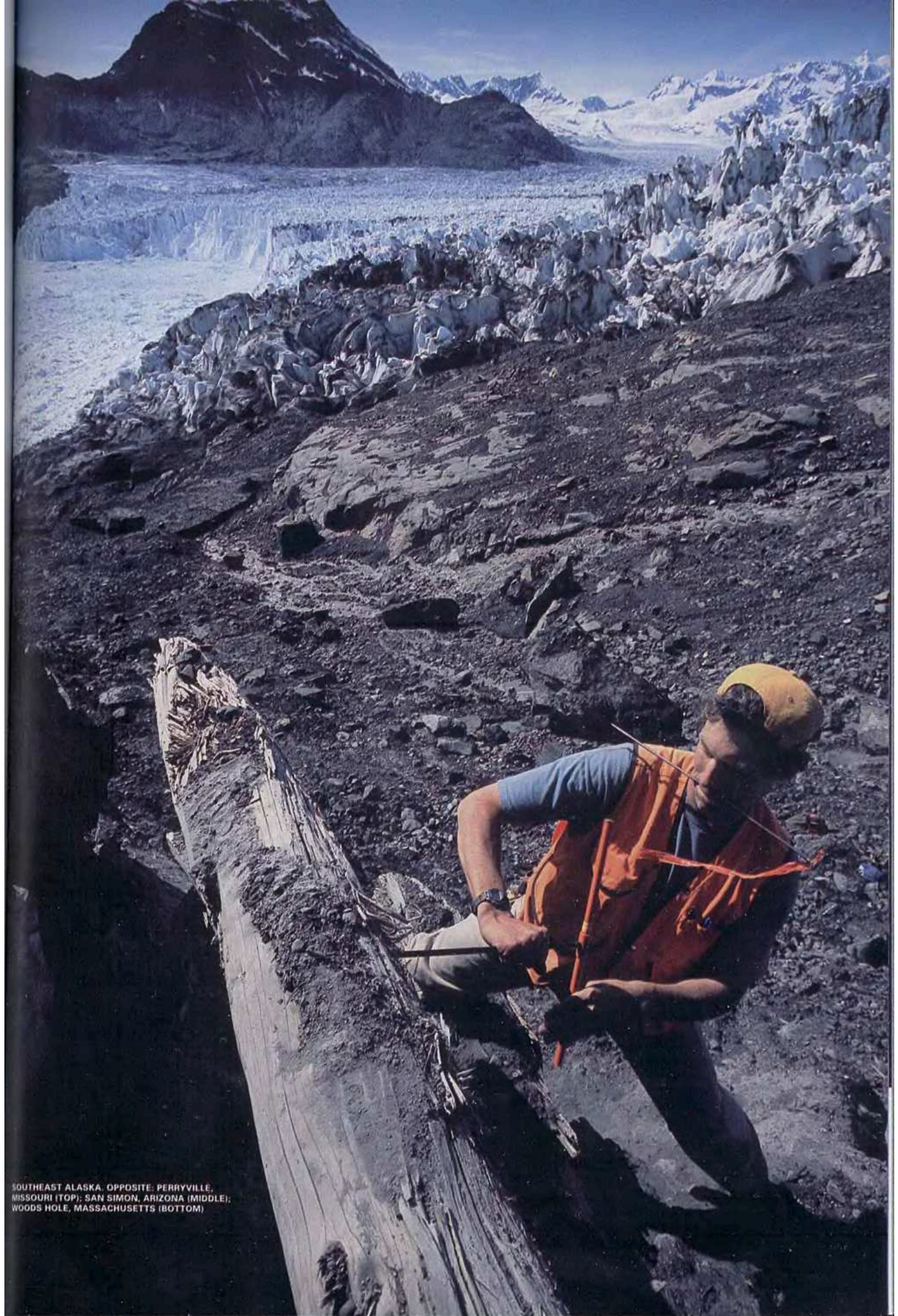


Pack Rats have been hoarding seeds, leaves, and twigs in the arid Southwest for more than 30,000 years. Preserved in crystallized urine, such middens give geologist Camille Holmgren (middle) a snapshot of an evolving landscape in Arizona's Peloncillo Mountains. During the last ice age the area was cooler, wetter, and covered with piñon pines and junipers.



Corals produce annual rings like trees. The density of a ring depends on sea surface temperature, which, according to Woods Hole researcher Anne Cohen (bottom), has risen dramatically off Bermuda in 50 years. "Those temperatures were pretty steady from 1850 to 1950," says Cohen. "Then boom! They just shot up. You can see global warming right there."

Tree Rings like those in a hemlock log buried for a millennium and uncovered by Alaska's retreating Columbia Glacier, give geologist Greg Wiles (right) an annual regional temperature record from A.D. 585 to the present. "Living trees seem to be experiencing stresses they haven't seen in the past thousand years," Wiles says.



SOUTHEAST ALASKA, OPPOSITE PERRYVILLE,
MISSOURI (TOP); SAN SIMON, ARIZONA (MIDDLE);
WOODS HOLE, MASSACHUSETTS (BOTTOM)

pollen in the mud, Whitlock takes smudges from every core at set intervals, then puts the mud in a chemical bath that eats away everything but the thousands of previously invisible pollen grains. She places a droplet of the pollen residue on a slide and then “reads” about 300 grains, identifying the species of each one—a process that allows her to trace how the vegetation in the Coast Range changed during the climatic variations of the past.

“You hit bedrock at the lake at about 18.25 meters,” Whitlock says, placing a sample slide beneath her microscope. “The pollen at that level dates to about 42,000 years ago.”

Very few mountain lakes have such a continuous record, she adds, since they are often formed when glaciers retreat. But a landslide that blocked a small stream before the last ice age made Little Lake. The pollen in its muddy sediments “tells us what the coastal Oregon environment was like before and at the height of that ice age and how it changed as the climate warmed about 13,000 years ago,” says Whitlock.

“It was a big change,” she continues. “Here’s what the forest looked like 21,000 years ago at the height of the last ice age. And, oh man, was it a different world.”

I take her place at the scope, and she guides me from grain to grain. It’s a surprisingly easy tour, since there are really only two types of pollen on this slide: the large, kidney-shaped grains of Engelmann spruce trees, and the smaller grains of mountain hemlock, which look like ovals with two small ears.

“Now think about this,” Whitlock says. “Engelmann spruce doesn’t grow in the Coast Range today. Instead, you find Douglas fir; that’s the dominant conifer. But there isn’t any Doug fir pollen on that slide. Doug fir doesn’t show up until close to the end of the last ice age, and then—suddenly boom!—it’s there and the spruce forest is gone. And that happens in 200 to 500 years: A whole forest vanishes and another one takes its place.”

Whitlock pauses. “So we want to know how that happened and why. What caused the forest and the climate to change so dramatically and abruptly? And what happens if the climate shifts in the other direction, toward an ice age again or toward even warmer conditions? How are we—people—going to respond?”

Ice cores from Greenland, first obtained and analyzed in the 1960s, gave scientists early clues to rapid climate change. Because the ice there has accumulated undisturbed for over 100,000 years, it holds some of the best records for such things as past temperatures, amount of precipitation, and atmospheric conditions.

The Greenland cores, combined with even older ice cores from Antarctica’s Vostok Station, showed the expected long periods of gradually increasing cold followed by shorter warm periods. But the Greenland ice also revealed that within the long, cold stretches there were short periods of warming and cooling. These shorter changes came in bursts, causing the climate to jump from cold to hot to cold again, sometimes in mere decades. The past climate had behaved like “an impish three-year-old” flicking a light switch, as Richard B. Alley, one of the scientists on the early 1990s Greenland drilling project,

Frozen History

Lonnie Thompson of Ohio State University holds an ice core from Peru’s Quelccaya ice cap, which is retreating 40 times faster today than in the 1960s. Thompson’s freezer may soon contain the sole remains of tropical glaciers from around the world, including the famed snows of Mount Kilimanjaro, which could vanish in 15 years. “What glaciers are telling us,” says Thompson, “is that it’s warmer now than it has been in the last 2,000 years over vast areas of the planet.”



wrote in his book *The Two-Mile Time Machine*. And that raised a new question, one that remains unsolved: What caused—and may cause again—all those flickerings?

Sudden climate flips occurred throughout the last ice age—from about 70,000 to 11,500 years ago. At the height of this glaciation, vast ice sheets blanketed much of North America, Europe,

"Some of the ice we have here is already gone from the mountains."

parts of Russia, and Antarctica. Periodically the ice melted, then advanced again, until the final melting—an event that marks the beginning of the modern warm (and more climatically stable) epoch known as the Holocene.

But getting to the Holocene was a start-stop affair. It began with an abrupt warming—probably the cause of Whitlock's suddenly altered forest. Then there was another switch, back to cold times, and yet another warming at 11,500 years. In that jump, Greenland's surface temperature increased by 15°F in a single decade. England warmed suddenly too, becoming a haven for certain beetles that can only live in balmy climes. And on both sides of the North Atlantic, the sudden warmth melted terrestrial glaciers thousands of years old in just a few hundred years.

"All those events happened essentially

OHIO STATE UNIVERSITY, COLUMBUS



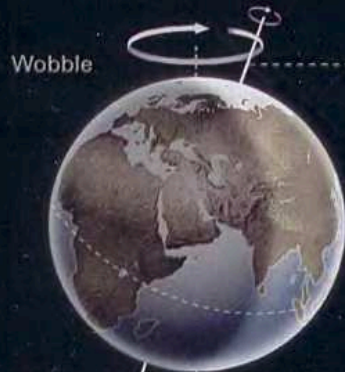
An ancient cycle ending?

Astronomical rhythms that affect climate >>>>

■ Earth in space

Earth's orbit around the sun and its orientation in space change regularly. Together these rhythms are thought to help set the timing of ice ages by affecting the distribution of sunlight over the Earth's surface. For most of the past 2.5 million years, Earth was moving through cool and warm cycles every 41,000 years. Then, about a million years ago, the climate cycles became about 100,000 years long.

■ A 400,000-year ice-core record from Vostok Station, Antarctica, suggests a link between ice ages and astronomical rhythms. During ice ages CO₂ levels drop.



Wobble

19,000- and 23,000-year cycle
Earth's tilted spin axis wobbles like an unsteady top, gradually making nearly a full circle in space.

Tilt of axis

41,000-year cycle
The tilt of the spin axis increases and then decreases again.



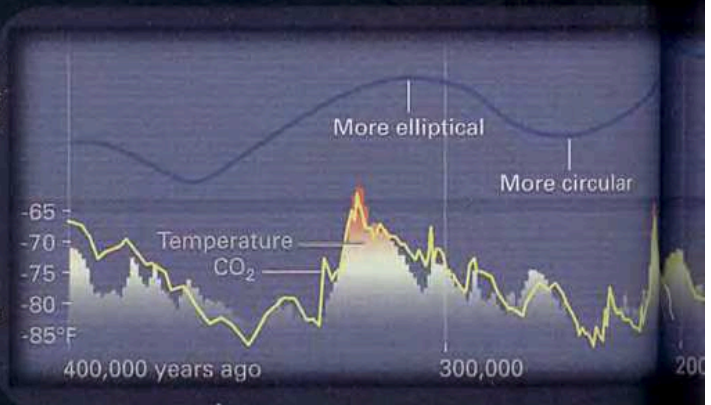
More circular orbit

100,000- and 400,000-year cycle
Earth's orbit around the sun expands and contracts between more circular and more elliptical paths.

NOT TO SCALE

Deviation in the shape of Earth's orbit

Average Antarctica ice surface temperature (minus °F)



■ Past Change

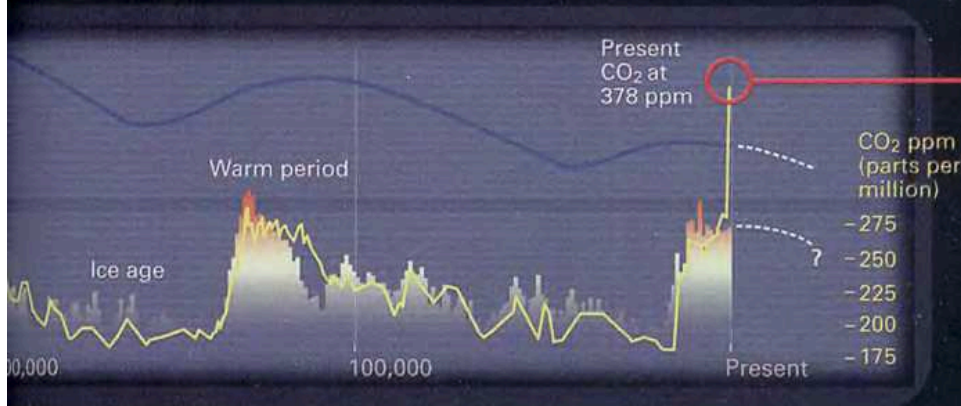
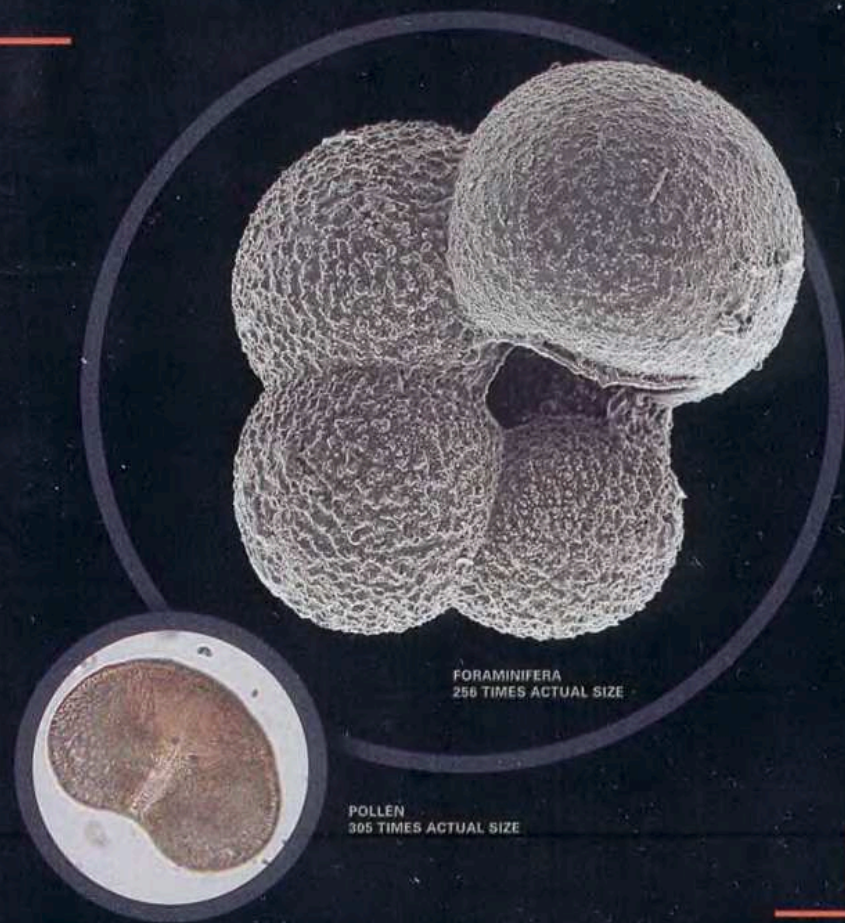
Ice cycles For the past 2.5 million years Earth's climate has cycled through ice ages. In the most recent episodes, ice grew over tens of thousands of years until it formed large continental ice sheets. It then retreated

quickly, and the Earth entered a warm interglacial period. Scientists believe this timing is partly determined by astronomical factors that affect the length of seasons and allow ice to build from one winter to the next.

Fossils as clues to past climate change >>>>

■ **Ancient sea life**
Fossilized shells of microscopic marine organisms called foraminifera contain a chemical signature of water temperature. In foraminifera from seafloor sediments, researchers can trace climate back for millions of years.

■ **Ancient plant life**
Fossil pollen grains record ancient vegetation—another climate indicator. This is a 20,000-year-old spruce grain from Oregon.



Astronomical patterns, historical data, and computer models suggest the Earth could be in an extended interglacial period. Increased atmospheric CO₂ could warm the planet further.

ART BY SW INFOGRAPHIC, JUAN VELASCO. ASTRONOMICAL CYCLES: JAMES ZACHOS, UNIVERSITY OF CALIFORNIA, SANTA CRUZ, AND ANDRÉ BERGER, UNIVERSITE CATHOLIQUE DE LOUVAIN, LOUVAIN-LA-NEUVE, BELGIUM. FORAMINIFERA: BRIAN T. HUBER, SMITHSONIAN INSTITUTION. POLLEN: CHRISTY BRILES, UNIVERSITY OF OREGON. VOSTOK ICE-CORE DATA: PETIT ET AL., NATURE, 3 JUNE 1999. PRESENT CO₂ DATA: C. D. KEELING, SCRIPPS INSTITUTION OF OCEANOGRAPHY

Following climate's ups and downs

With no temperature records from ancient times, scientists turn to clues left in ice or in sediments from the oceans and lakes. Past air temperatures affected the chemical

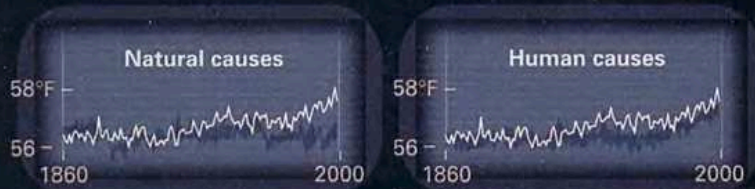
makeup of the snow that fell to form today's ice sheets. Ocean temperatures are recorded in certain marine organisms. And ancient fossil pollen reveals vegetation type, another indicator of climate.

What's ahead for the planet?

Climate models vs. observed temperature >>>

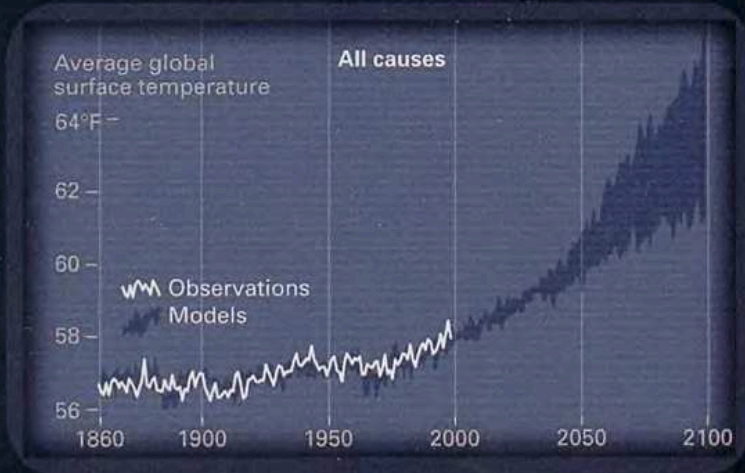
■ Not the whole story

Computer models that include only natural (left) or human (right) influences on climate can't match the planet's observed warming.



■ A persuasive match

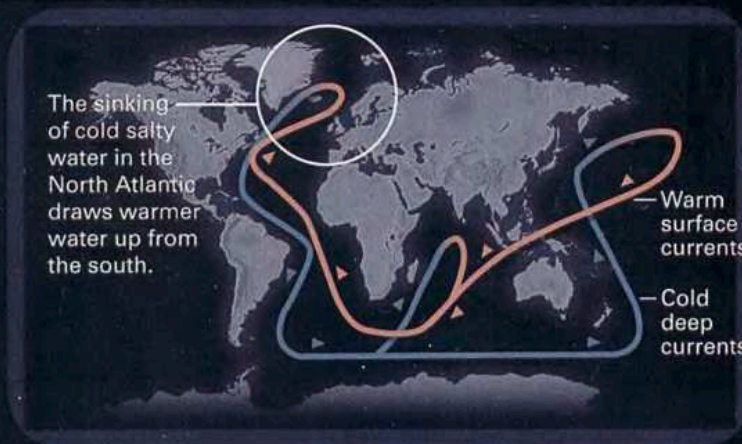
A model that includes both natural influences and human ones like greenhouse gas emissions closely tracks the observed warming—and projects that it will continue.



Global ocean circulation system >>>>>

■ Climate paradox

Fresh water flowing from melting Arctic ice into the North Atlantic could disrupt the global system of ocean currents. Although Europe would warm with the rest of the world, its winters might cool.



Future Change

ART BY 5W INFOGRAPHIC, JUAN VELASCO. CLIMATE MODELS: HADLEY CENTRE FOR CLIMATE PREDICTION AND RESEARCH, U.K. OCEAN CIRCULATION SYSTEM: JAYNE DOUCETTE, WOODS HOLE OCEANOGRAPHIC INSTITUTION

Climate crystal ball Most scientists agree that human activity—the burning of fossil fuels and the clearing of forests—is a major cause of the global warming observed so far. They predict that the warming trend will

continue as greenhouse gases increase. But no one knows whether the climate change will be gradual or swift, occurring in years instead of decades. One reason is that ocean currents play a key part in global climate,



LIVENGOOD, ALASKA



MISSISSIPPI RIVER AT QUINCY, ILLINOIS; JIM RICHARDSON



FARSON, WYOMING

carrying heat from the tropics around the planet. Computer models project that continued warming could trigger a rearrangement of currents, perhaps leading to abrupt climate changes in parts of the world.

overnight," says Oregon State University's Peter Clark, who is tracking climate changes in Ireland's glacial geology. "We'd like to understand why the sudden retreats happened—what triggered them and if something like that could happen today," says Clark. "But to get those answers, we first need to know as precisely as possible when the ice melted."

In an effort to answer that question, Clark and fellow geologist Marshall McCabe from Ireland's University of Ulster don their rain gear and knee-high rubber boots, grab shovels and plastic bags, and make their way to a muddy cliff in a farmer's pasture above Ireland's Atlantic coast. Along the way, McCabe points his shovel at a small palm tree planted outside the farmer's house. "You know, we're at the same latitude here as southern Alaska. And that palm shows that our friend,

the North Atlantic Ocean conveyor, is working," he says, referring to the ocean currents that pull warm water from the tropics to the Irish coast, keeping its temperature mild. "Otherwise, the palm would be dead."

From their studies of coral reefs and marine sediments, paleoclimatologists have shown just how important this ocean circulation system—the North Atlantic conveyor—is to the climate of the entire planet. During the

ice ages it weakened and even occasionally stopped, triggering a cascade of events that ultimately led to warmer temperatures in the Southern Hemisphere and colder temperatures in the north.

"That conveyor sits right offshore," McCabe adds, this time aiming his shovel toward the sea. "So Ireland is particularly sensitive to any big changes in what it's doing; they're felt here immediately."

In the last ice age, with the conveyor slowed down, Ireland was much more like Alaska. Glaciers covered its mountains and pushed across the land and into the sea. But whenever the climate switch was flipped and the deep freeze

momentarily ended, Ireland's glaciers began to retreat—rapidly. Meltwater coursed over the land, cutting deep river-size channels and pouring a slurry of mud into the sea. “These were high-energy events,” says McCabe.

As the mud settled, tiny organisms called zooplankton were buried in the sediments. Today, with relative sea level far lower than in the past because the land is no longer weighted with ice, those muddy deposits are up to several hundred feet above the ocean, and a geologist who knows where to look can find in them the fossils of the shell-covered zooplankton called foraminifera (forams for short). Forams are an integral part of paleoclimatological research because their calcareous shells can be dated. And that's why McCabe and Clark have come to this pasture: to dig about 50 pounds of foram-filled mud for dating. With precise dates for the rapid retreat of the ice in hand, the two will be able to

link Ireland's glacial history with that of North America and Scandinavia.

By dating forams from mud on the Irish Sea coast, McCabe and Clark found evidence for a rapid 35-foot rise in global sea level about 19,000 years ago. “That was a Northern Hemisphere melting, a pulling back of the entire ice margin,” says Clark. “It wasn't just a little local event. We figure that the equivalent of two ice sheets the size of Greenland's today must have melted within a few hundred years.”

What could have triggered such a large-scale event? McCabe and Clark argue that it could have been the weight of the ice itself. As the ice sheets grew, their increasing weight pushed down on the underlying land. Where the glaciers sank far enough to reach sea level, the ice began to float, breaking up into icebergs. “That would have added more fresh water to the ocean, changing its salinity and deepwater currents,” says Clark.

ATLANTA, GEORGIA



“What happens if the climate shifts in the other direction, toward an ice age again or toward even warmer conditions?”

More fresh water in the North Atlantic would have slowed the conveyor and decreased the amount of warm water pulled from the tropics, changing ocean circulation dynamics and temperatures as far south as Antarctica. Computer models that simulate the Earth's climate show that what happens in the North Atlantic very quickly affects the rest of the planet. “As the water gets cooler here, the ocean gets warmer in the Southern Hemisphere,” says Clark. “It’s a seesaw

effect. That warming could have caused an ice sheet in Antarctica to melt.”

And that additional cold fresh water from Antarctica would, in turn, have caused the tropical warm currents to flow back toward the north, starting up the North Atlantic conveyor. Once again the Northern Hemisphere ice sheets would have begun to melt.

“You essentially would have ended up with ice sheets melting at both ends of the Earth at slightly different times,” says Clark. “Today we have two big ice sheets: Greenland and Antarctica. And the climate is changing because of the high amount of carbon dioxide we’ve put in the atmosphere. How will it affect those ice sheets? If they melt, how will that affect us?”

Heat Wave

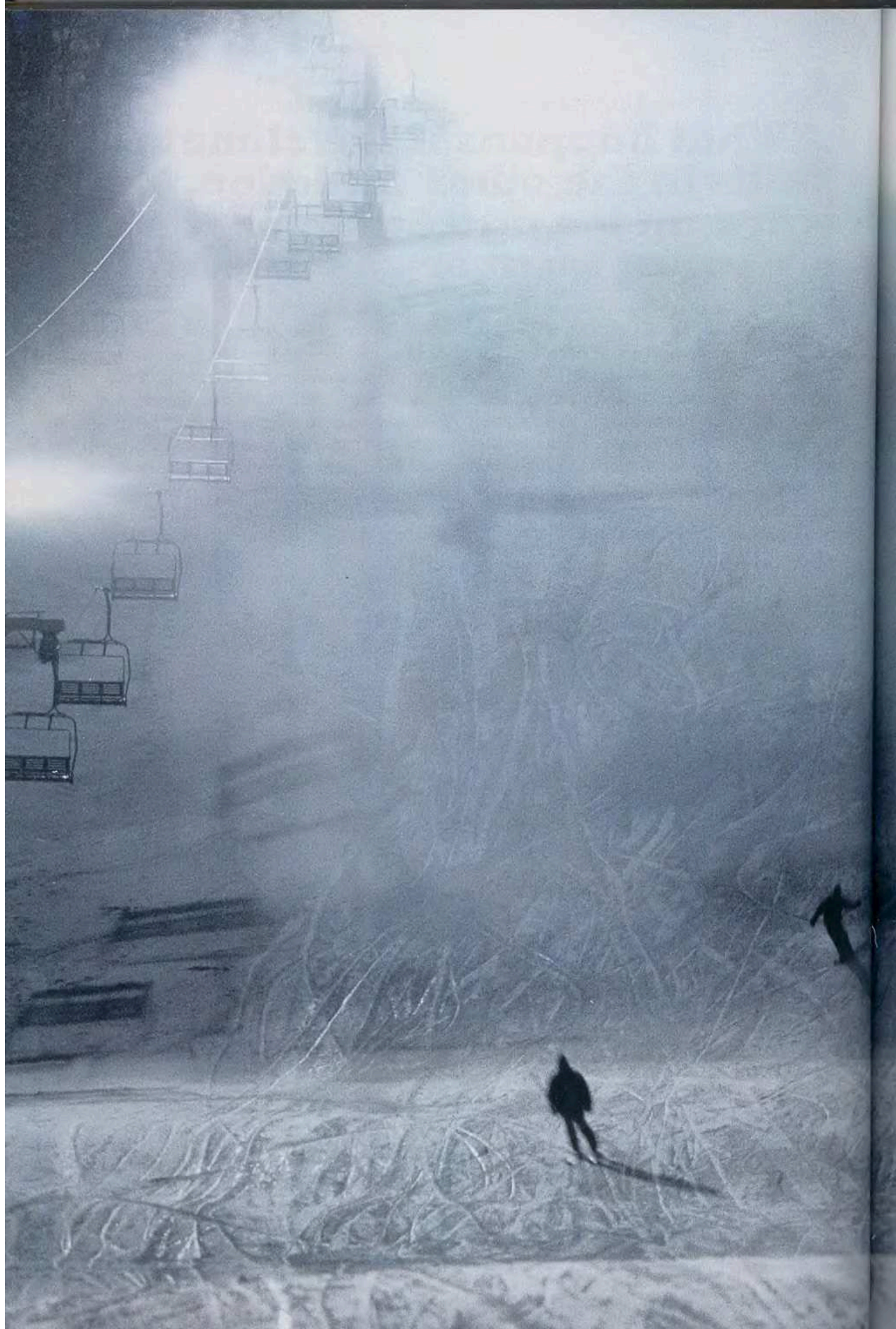
Kids cool down in Atlanta’s Centennial Olympic Park on a 90°F day. Using global climate models, scientists say temperatures in Georgia could rise one to nine degrees Fahrenheit over the next century. Higher temperatures and more frequent heat waves could double the number of heat-related deaths in Atlanta by 2050.



Not everyone is convinced that the North Atlantic Ocean conveyor is the only switch for the Earth’s sudden climate changes. “Maybe that’s true for the higher latitudes, but it’s not for the tropics,” says Lonnie Thompson, whom many credit with retrieving the best paleoclimate records from the torrid zone—the latitudes between the Tropic of Cancer and Tropic of Capricorn. Indeed, until research by Thompson and others showed something different, most scientists regarded the tropics as a place where little climate change had ever taken place—not even during the ice ages.

“There’s a bias in our view of climate change that sees events in the Northern Hemisphere as the most important,” Thompson explains as we gear up to enter his ice-core storage room in the basement of Scott Hall on the Ohio State University campus. “But it’s a data-collecting bias: That’s where we have the most records from.”

Behind a nondescript, beige door marked 089-B lie 6,000 meters of ice cores that give Thompson the data to challenge that interpretation. The cores come from glaciers crowning summits in the Andes, the Himalaya, and





Troubled Slopes

Skiers glide on man-made powder at a resort in central Wisconsin that cannot depend on natural snowfall. The skiing industry would be hit hard by a warmer world, with ski areas contracting to higher elevations, resorts enduring shorter seasons, and operators forced to make more snow. In nearby southern Ontario the length of the ski season could be cut in half by 2080.

CASCADE MOUNTAIN, WISCONSIN

Alaska, and from Mount Kilimanjaro. I'm glad for the down-filled parka, gloves, and snow boots when the first blast of arctic-cold air from Thompson's ice room hits my face.

The cores are kept in silvery, cardboard cylinders and lie in stacks on frost-covered shelves. A temperature gauge reads minus 30°C (minus 22°F), and I shiver in spite of the down. But the numbing cold is necessary to preserve what has or will soon disappear: the climatic history of the tropics. "The sources for these records—the glaciers on the highest mountains—are melting because of the increasing greenhouse gases in the atmosphere," Thompson says. "Some of the ice we've collected and have here is already gone from the mountains."

Greenhouse gases, such as carbon dioxide and methane, are released by a variety of human activities. Over the past 150 years, the amount of these gases has increased enormously in the Earth's atmosphere, trapping more heat and causing temperatures to rise—and glaciers worldwide to melt. And as the ice melts away so do the records that Thompson and other scientists deem vital to a better understanding of Earth's climate.

Thompson pulls down one of the cardboard containers and carries it to a table, handling it as carefully as if it were a tome from a library's rare-book room. "We forget that the Earth is a globe and that 50 percent of the surface of the planet is in the tropics. That's a major heat source, and I think it has a much bigger role in driving climate change than we've realized."

Thompson opens the cylinder and pulls out a meter-long ice core that's wrapped in plastic.

"This is a core we drilled on Sajama mountain in Bolivia," he says. It is dense and white, yet as Thompson points out, it also has slight variations, the faintest ringlike bands, indicating the annual accumulations of snowfall. By counting the bands, he can estimate the age of a core. And this one, Sajama's final core, the last one Thompson pulled from the mountain's ice before hitting rock, dates to 25,000 years ago, making it the oldest core Thompson has found in his high-altitude work in the tropics.

"This core shows that there actually were climate shifts in the tropics of the same magnitude that Greenland experienced during the ice ages," he says. Near the Equator, Earth's climate had switched rapidly back and forth from cold to warm just as it had in Greenland. And that



Projections for the 21st century:

- **Higher minimum temperatures, fewer cold and frost days over nearly all the planet's land areas.**
- **Fastest climate warming in the past 10,000 years.**

makes Thompson think that the North Atlantic isn't the only driving mechanism for these abrupt changes. There may be a second driver in the Pacific Ocean.

Other anomalies in this high-mountain ice suggest that the past 10,000 years, which is often characterized as a stable climate period, was in fact also given to climate swings. Thompson opens

another cylinder and produces a core from the ancient snows of Mount Kilimanjaro. Like the Sajama core, it is dense and white—except for a two-centimeter-thick band, which is black.

"That's dust," says Thompson. "It dates to 4,200 years ago when there was a terrible 200-year drought in North and East Africa. The upper atmosphere must have been full of sand, dirt, and dust, all of which mixed with the snow as it fell on Kilimanjaro."

Hieroglyphic inscriptions from the period describe how the annual Nile flood failed for about 50 years. The Egyptians suffered in a drought, and people died from famine. At about this time Egypt's Old Kingdom ended, and a period of social and political upheaval began. Thompson believes that the dry spell contributed to the collapse of the Old Kingdom. Some archaeologists also think that the drought extended north into the eastern Mediterranean and contributed to the decline of the Akkadian empire in Mesopotamia.

"It shows what climate change can do," says Thompson. "That was an abrupt, but natural, occurrence, when there were only 250 million people on the planet. Now there are 6.3 billion of us, and we're changing the climate."

Every paleoclimatologist I'd spoken to had said much the same thing. Some were certain that we had already succeeded in flipping one of Earth's climate switches and had triggered a new abrupt change. Others were more cautious, saying only that given the steady emission of carbon dioxide and other gases, the climate was bound to be different. All were alarmed by our collective refusal to slow down our use of fossil fuels. One wryly summed up our behavior as a



Contrasting Impacts

A warming world will harm some—and benefit others. Home heating costs will likely fall in New England, while power bills in Florida will rise as demand for air-conditioning grows—giving Miami appliance salesman Elbris Paz (above) reason to smile. The prospects are grim for drought-plagued Ethiopian children (below), who could see rainfall decline by 10 percent over the next 50 years. Widespread poverty and dependence on subsistence agriculture make Africans the most vulnerable to climate change.

MIAMI, FLORIDA (ABOVE); GEMETO, ETHIOPIA (BELOW)





Hitting Home

Without expensive erosion control and beach replenishment, resorts along the South Florida coast could be hit hard by a rising sea. Poorer low-lying nations like Bangladesh could be devastated. As evidence mounts of a warming world, scientists agree: The changes are becoming less subtle.

HOLLYWOOD BEACH, FLORIDA

“remarkable experiment,” a quip I pass on to Thompson as we leave his ice-core room.

“He forgot one word,” Thompson says, ready as ever to add to the record what is missing. “It’s a remarkable, *uncontrolled* experiment.”

The climate of the past is our anchor for looking at the future,” Cathy Whitlock told me when explaining the importance of her fossil pollen studies. “If we can understand the past linkages between the ocean, atmosphere, and biosphere, and determine which parts were the really big players in past sudden change, then maybe we can better deal with future surprises.”

That’s the dream, the goal of paleoclimatology. And although all the connections among the disparate parts of the Earth’s climate have yet to be fully untangled, computer modelers have made big steps in predicting what the weather will be in the near future. One of the best models runs on a supercomputer at the United Kingdom’s Hadley Centre for Climate Prediction and Research. Simon Tett, a Hadley Centre climate specialist, sets up his laptop at my London hotel and calls up a map of the world. Superimposed on it are swirls and colors representing ocean and atmospheric currents—essentially a model of Earth’s climate. Plug in different factors, like a big spike in CO₂ and methane levels, and you can sit back and watch the weather change.

“Right. So here is what the world’s climate could be in 2080,” Tett says. A red hue settles over most of North America and Europe, indicating higher temperatures, while the Arctic turns from white to blue as the summer ice cap melts.

“People don’t realize how dramatic these changes will be,” says Tett. “But we expect to see a two- to five-degree [Celsius] warming over the next hundred years. It will be higher over land, but the oceans will also warm.”

The warming doesn’t mean that every place will suddenly become like Miami. Some areas, like the interior of the United States, are likely to grow hotter and drier. Others, like China, Southeast Asia, and the western U.S., may get more precipitation but less snowfall, jeopardizing the drinking water of people in cities like Los Angeles. Sea levels around the world are projected to rise as the last of the glaciers melt and

the warmer oceans expand. Intense hurricanes may occur more frequently, and storm surges coupled with the higher sea level could severely damage cities like New York. Heat waves, like the one Europe experienced in the summer of last year, may become the summer norm.

Can we do anything to stop the change?

“No,” says Tett. “We’d need to get to zero emissions to stabilize the CO₂ that’s already in the atmosphere. And that’s not the path we, as societies, have chosen. Even if we were to stop CO₂ emissions now, we are committed to warming.

“Ultimately there will be an effect on the ocean’s thermohaline circulation—the conveyor belt,” he continues. “Climate models show that

“We’ll have a better idea of the actual changes in 30 years. But it’s going to be a very different world.”

circulation will slow, but it’s possible that it could collapse. One result of that would be cooler winter temperatures in Europe.”

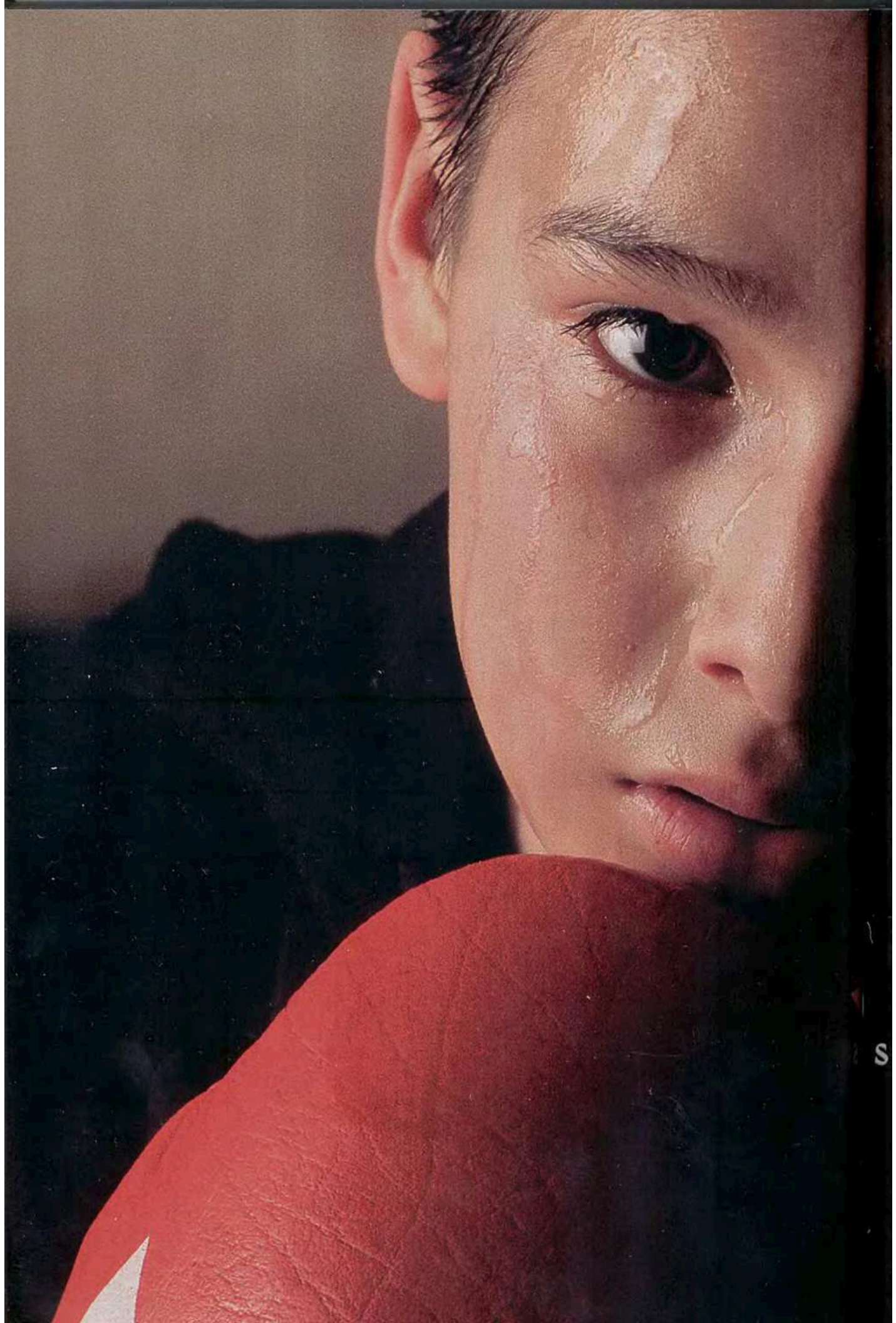
Tett turns off his laptop. “We’ll have a better idea of the actual changes in 30 years, because some of us will have lived through them. But it’s going to be a very different world.”

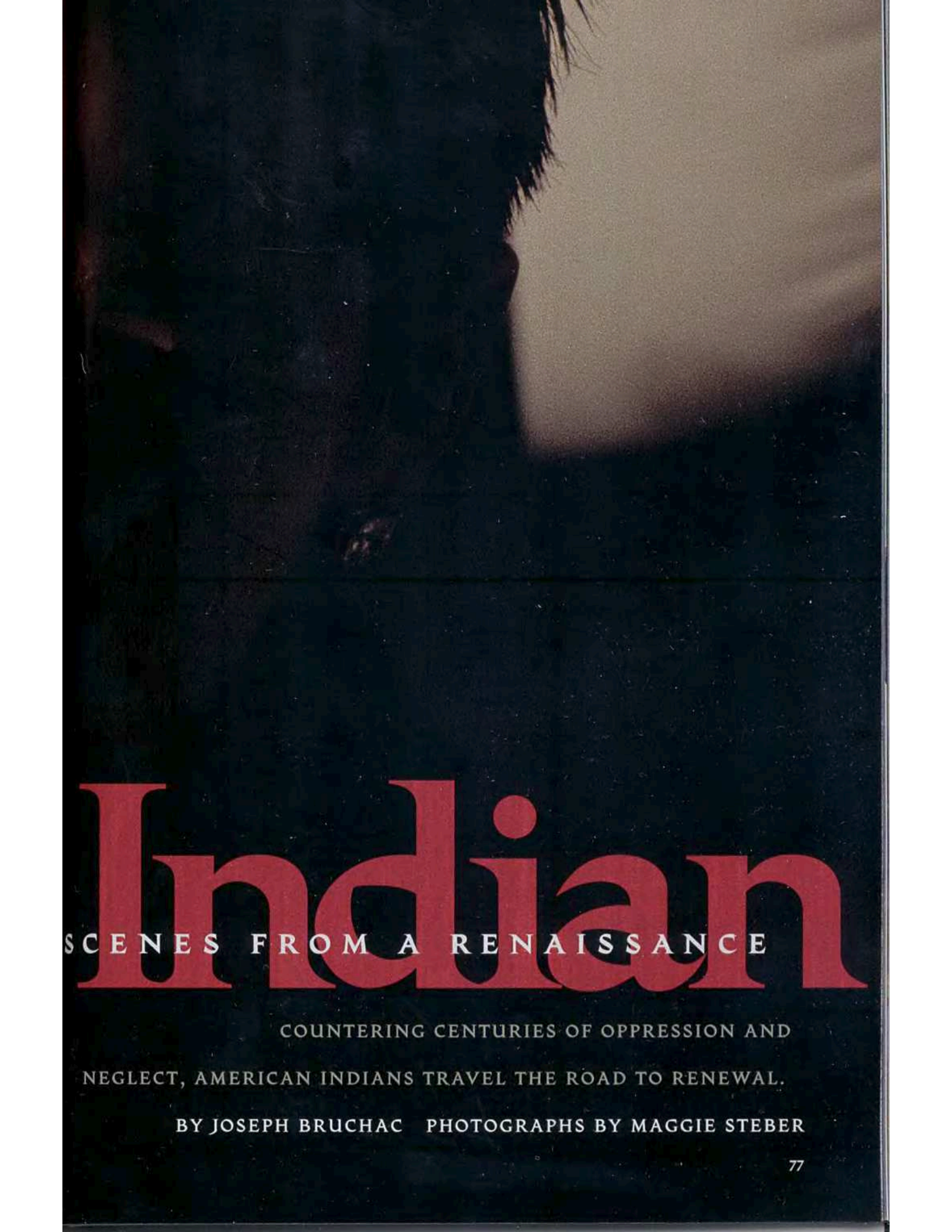
Outside, the light of a cold winter sun spills over the London streets. It’s a week before Christmas and shoppers bustle by. There’s the whoosh and honking of traffic, and the smell of diesel and gasoline fumes rising in the air. I hail a cab and set off for the airport.

“The weather’s going to change,” the cabbie tells me. “It’s fine now, but that’s the end of it; it’s turning rough tomorrow.”

I nod in agreement. He is more right than he knows. □

PREDICTING EARTH’S FUTURE What do tree rings, pack rats, and stalagmites have in common? Test your climate knowledge with an interactive quiz. Then read field notes and find related resources at nationalgeographic.com/magazine/0409.





Indian

SCENES FROM A RENAISSANCE

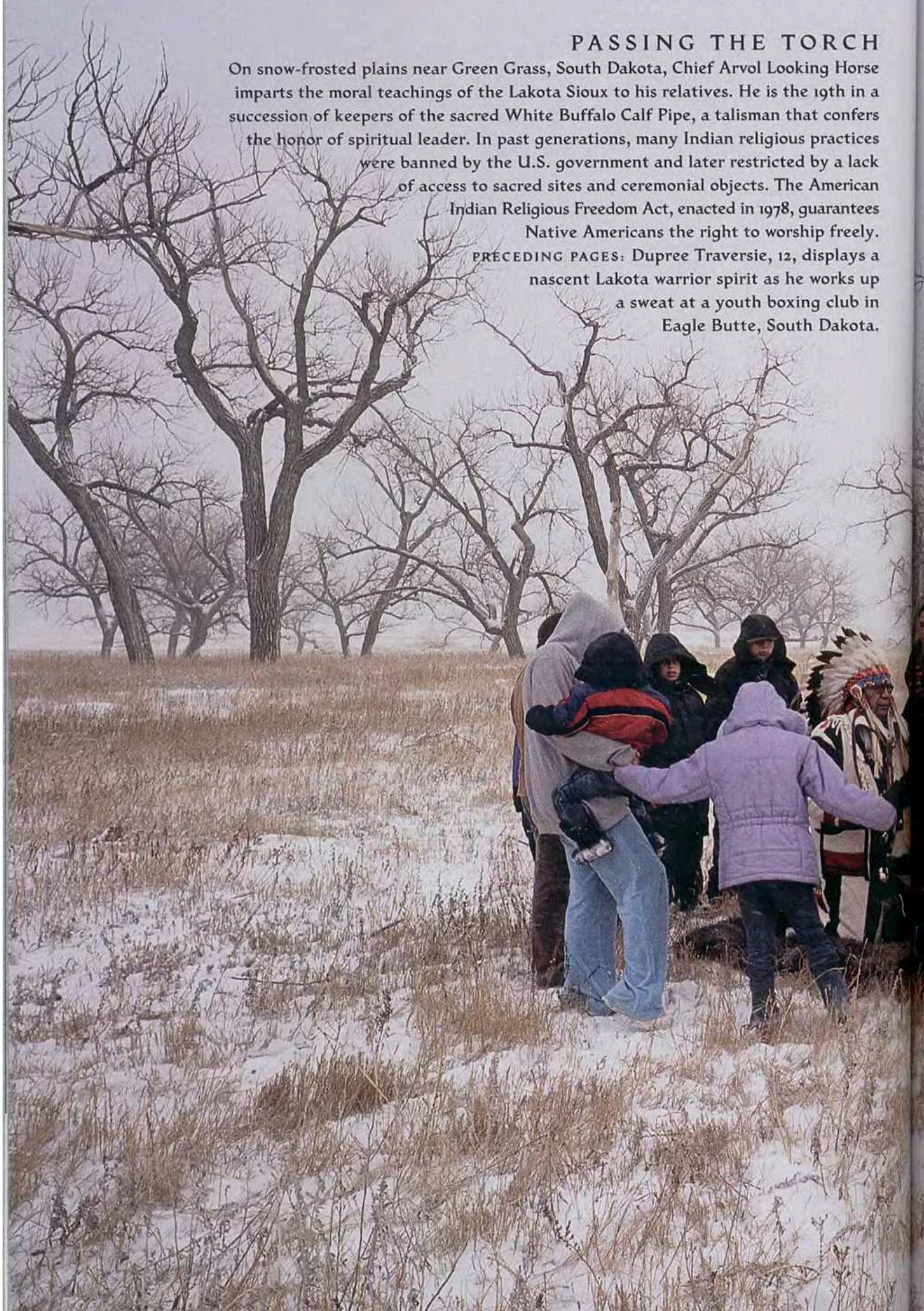
COUNTERING CENTURIES OF OPPRESSION AND
NEGLECT, AMERICAN INDIANS TRAVEL THE ROAD TO RENEWAL.

BY JOSEPH BRUCHAC PHOTOGRAPHS BY MAGGIE STEBER

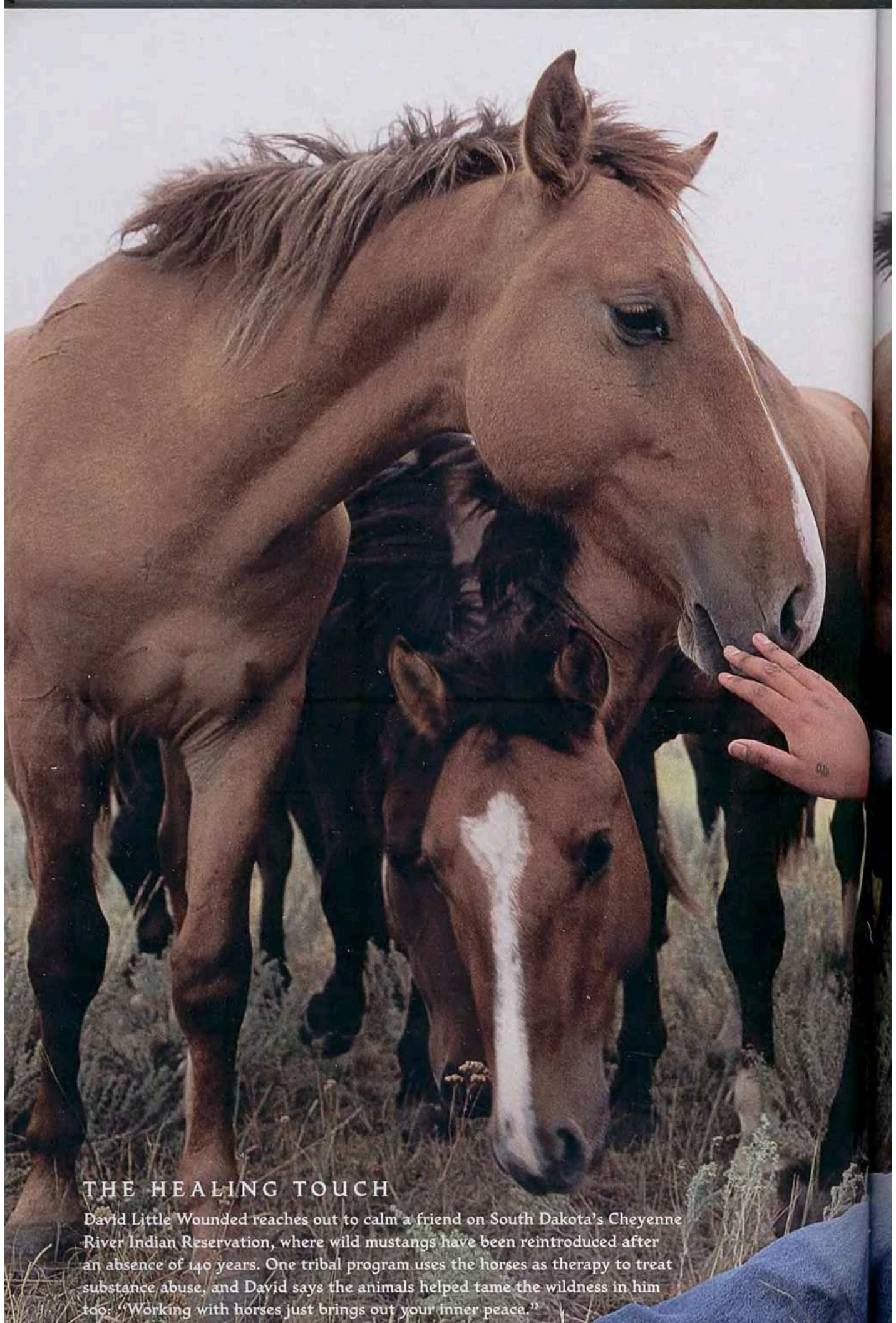
PASSING THE TORCH

On snow-frosted plains near Green Grass, South Dakota, Chief Arvol Looking Horse imparts the moral teachings of the Lakota Sioux to his relatives. He is the 19th in a succession of keepers of the sacred White Buffalo Calf Pipe, a talisman that confers the honor of spiritual leader. In past generations, many Indian religious practices were banned by the U.S. government and later restricted by a lack of access to sacred sites and ceremonial objects. The American Indian Religious Freedom Act, enacted in 1978, guarantees Native Americans the right to worship freely.

PRECEDING PAGES: Dupree Traversie, 12, displays a nascent Lakota warrior spirit as he works up a sweat at a youth boxing club in Eagle Butte, South Dakota.

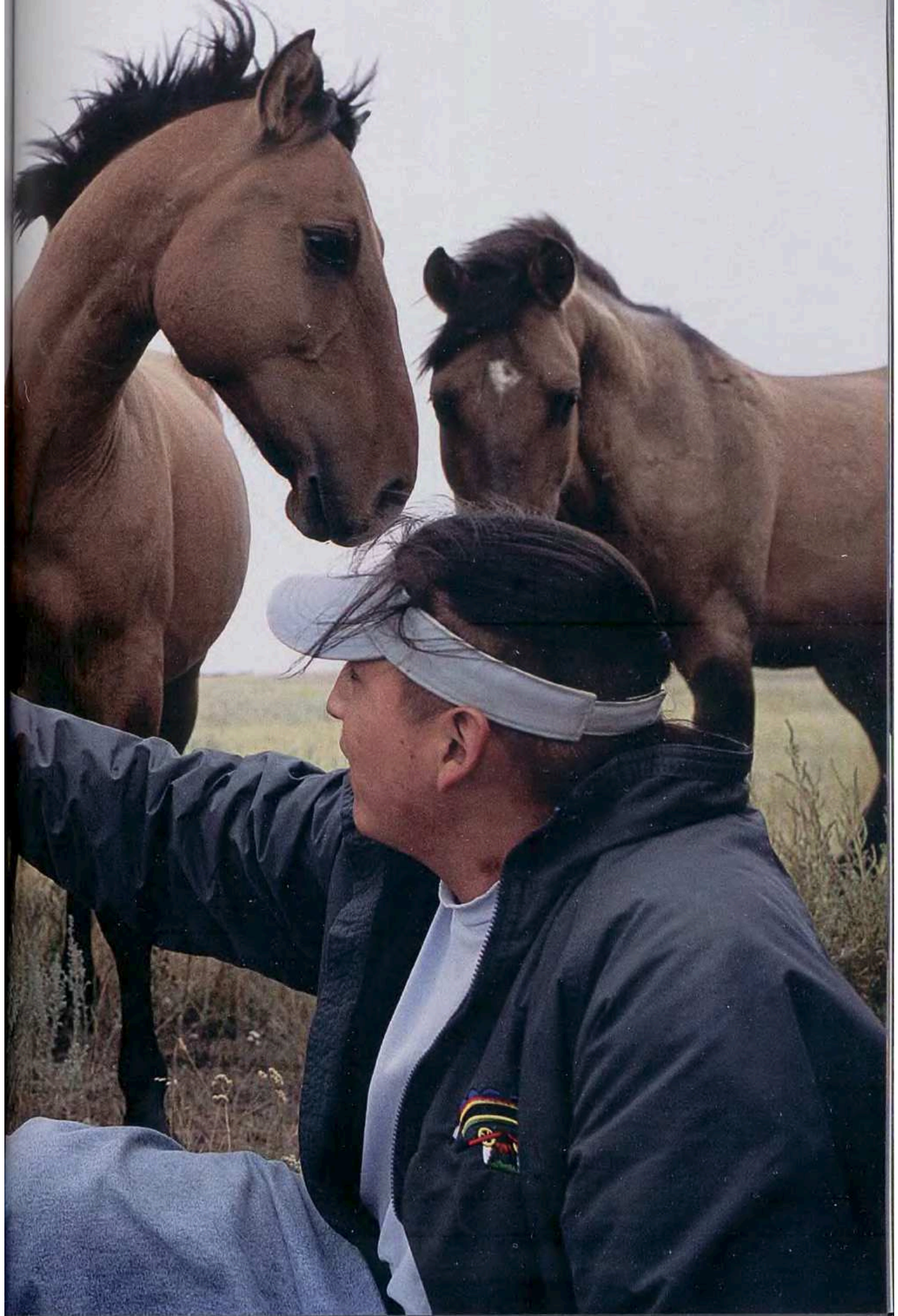






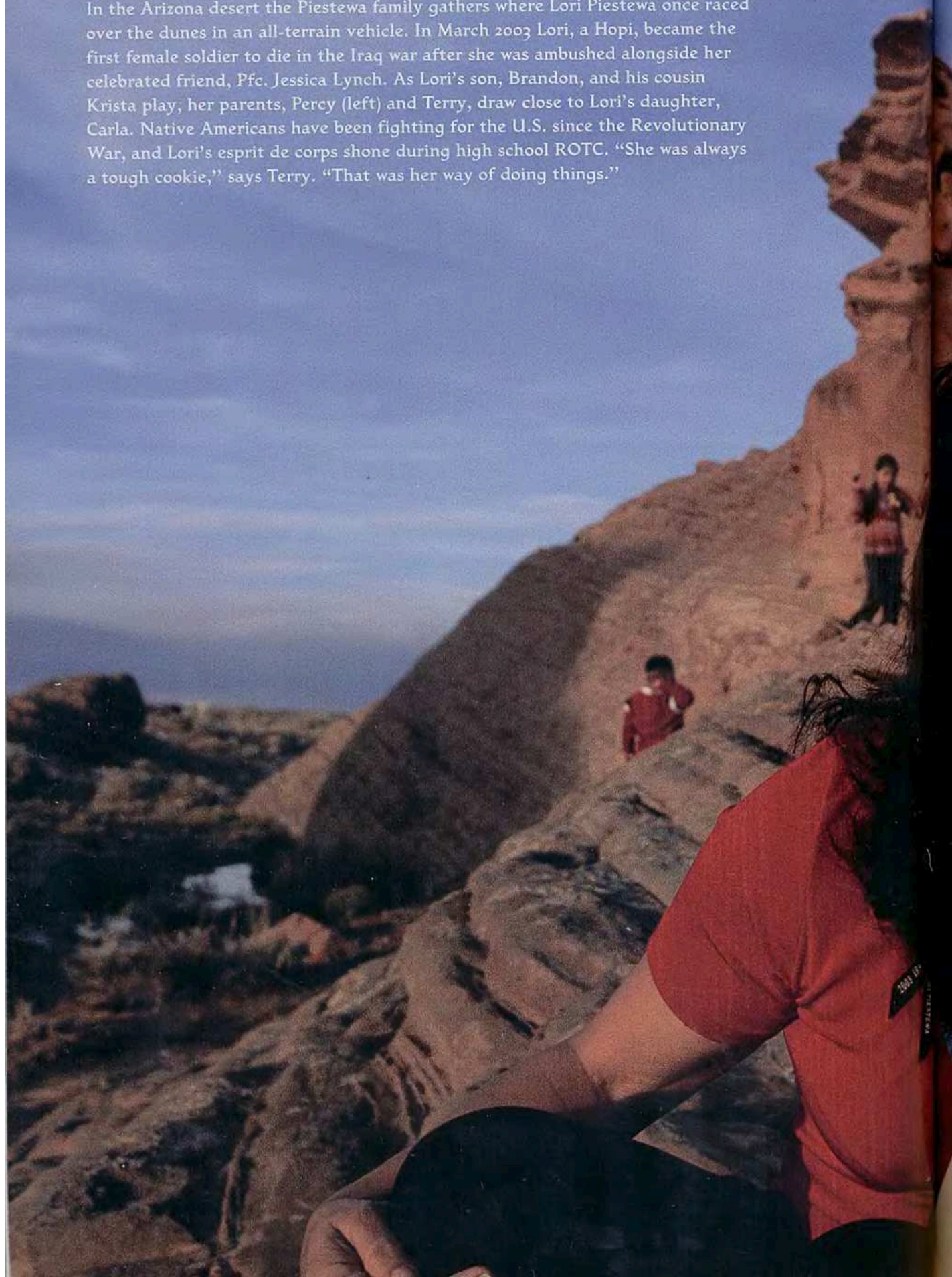
THE HEALING TOUCH

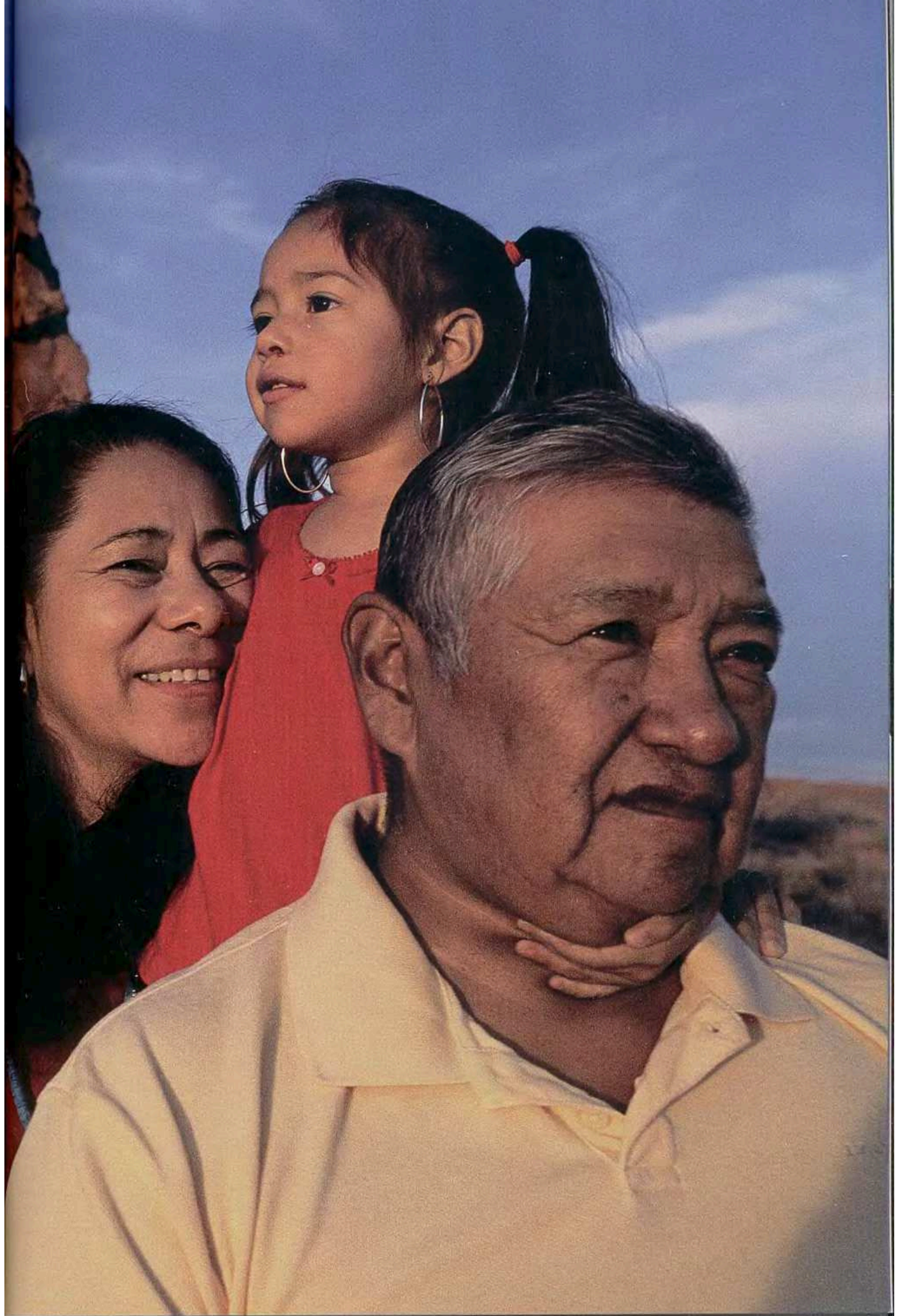
David Little Wounded reaches out to calm a friend on South Dakota's Cheyenne River Indian Reservation, where wild mustangs have been reintroduced after an absence of 140 years. One tribal program uses the horses as therapy to treat substance abuse, and David says the animals helped tame the wildness in him too: "Working with horses just brings out your inner peace."

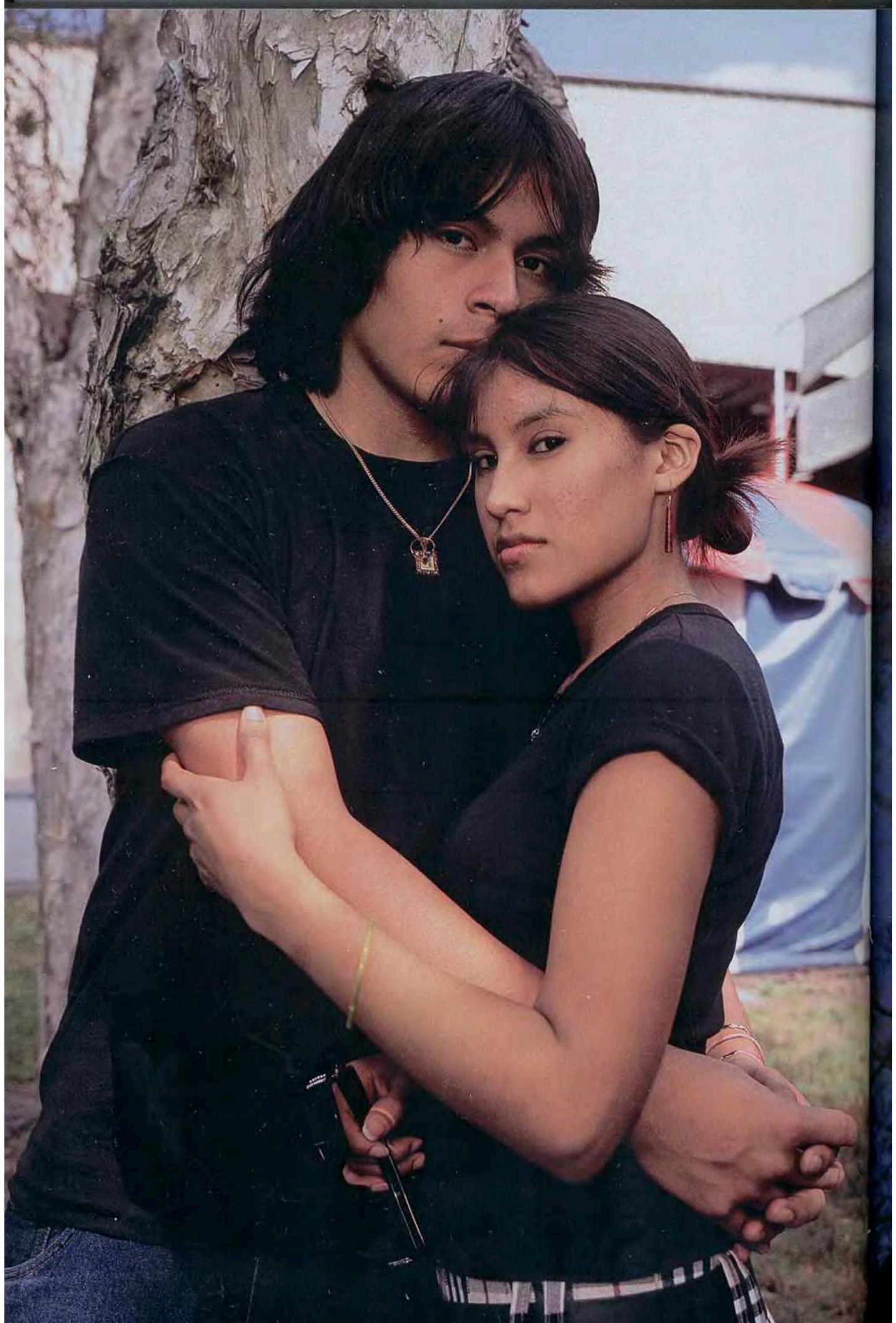


HEART OF A WARRIOR

In the Arizona desert the Piestewa family gathers where Lori Piestewa once raced over the dunes in an all-terrain vehicle. In March 2003 Lori, a Hopi, became the first female soldier to die in the Iraq war after she was ambushed alongside her celebrated friend, Pfc. Jessica Lynch. As Lori's son, Brandon, and his cousin Krista play, her parents, Percy (left) and Terry, draw close to Lori's daughter, Carla. Native Americans have been fighting for the U.S. since the Revolutionary War, and Lori's esprit de corps shone during high school ROTC. "She was always a tough cookie," says Terry. "That was her way of doing things."



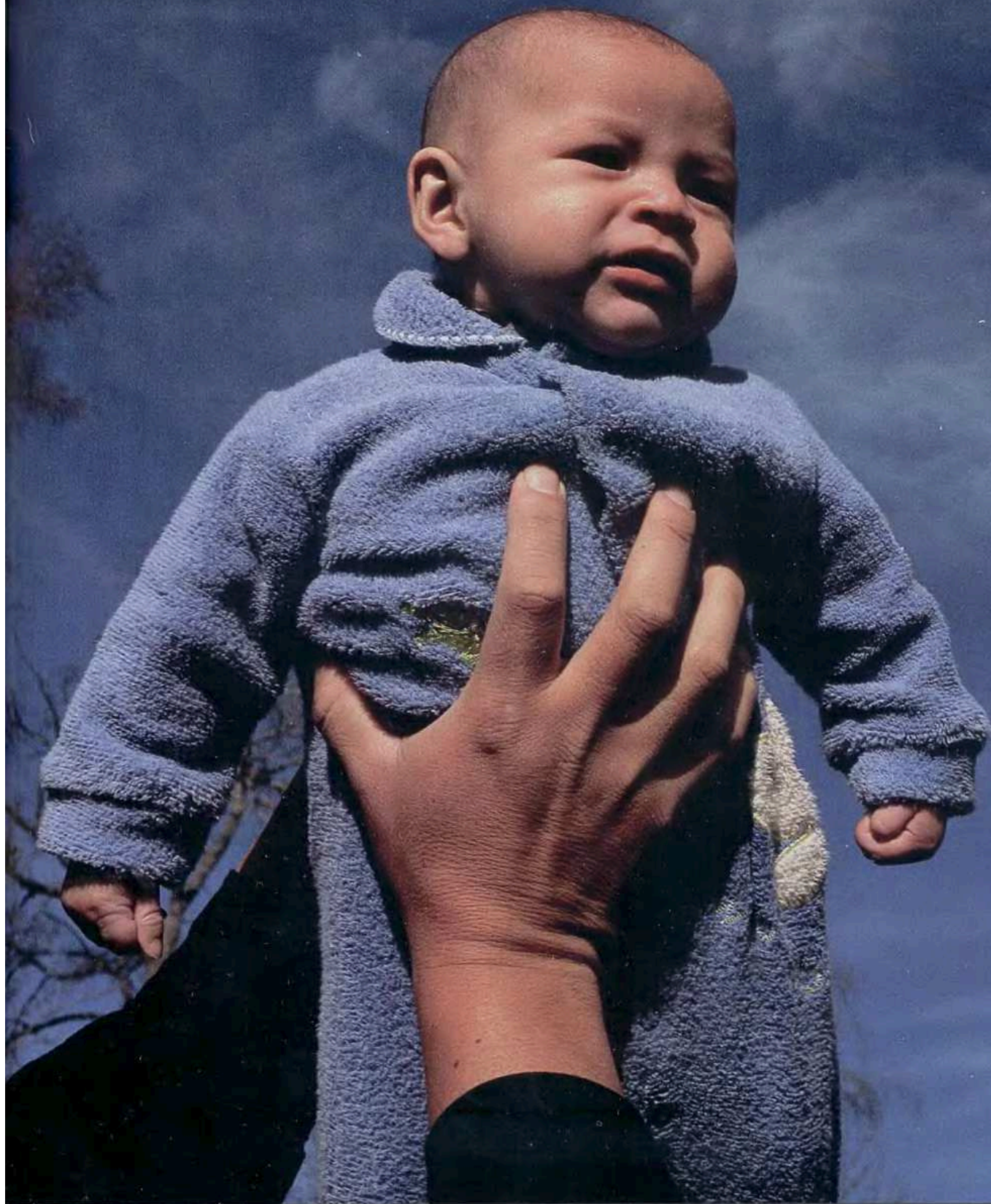




A NEW GENERATION

Byron Billie and JoJo Dakota Osceola (left), both full-blooded Seminoles, changed into typical teen garb after winning awards for native costume at a Seminole cultural fair in Davie, Florida. Though immersed in mainstream youth culture, "I most definitely identify more with my Indian heritage," says Byron. JoJo hopes to become an attorney specializing in Indian law.

In Park Hill, Oklahoma (below), three-month-old Skylar Wildcat gets a lift from his father, Lucas, at a Thanksgiving get-together. The Wildcat clan teaches its children the stories and songs of the Cherokee. When Skylar turns one, the event—as with most family birthdays—will be celebrated with a stomp dance on the family's ceremonial grounds in the yard of Skylar's aunt.



From the top of Coffee Butte in the land of the Cheyenne River Sioux, you can see 50 miles in every direction. As I circled my gaze, I could see black dots on the wide, grassy plain below. Buffalo. I picked out one herd, then another, another and another. A herd in each of the four directions: good omen.

"Look," said Dennis Rousseau, of the tribe's Game, Fish, and Parks Department, "over there."

I followed his stare to a group of brown specks on a ridge, two miles to our east. "Wild horses," he said. "Coming our way."

I watched as perhaps a dozen animals flowed toward us down the slope, smooth as rushing water. They were half a mile away, led by a brown stallion, head up, alert to any danger. Sure enough, distant as we were, the stallion caught wind of us. He stopped abruptly on top of a hill, stared, then turned, driving the horses before him, out of sight as quick as the flash of a hawk's wing.

Wild horses are back on the reservation after an absence of 140 years, trucked in from Nevada, where they were being shot at and killed by poachers only a few years ago. Their return, like seeing buffalo in all directions, was enough to stir the blood of at least one old East Coast Indian: me. For the first time in generations, "the buffalo, the elk, and the mustang are all back on the reservation," said Dennis, lowering his binoculars. "One of our holy men told me that means something really good is going to happen."

I'd come to Cheyenne River looking for something good: the same spirit of revival and hope that I'd heard about in Indian communities across the United States, from the stone-cold canyons of Manhattan to the quietest hogan in the desert Southwest. In a thousand small ways, that revival—cultural, political, economic, spiritual—may wind up transforming the lives of 4.1 million Native Americans, the vast majority of whom today live somewhere besides a reservation.

And yet, as I'd driven across South Dakota to get here, I'd expected this place to be different. Confined to some of the driest, most unforgiving real estate in North America, Sioux

reservations on the Great Plains are among the poorest in the country. Just south of Cheyenne River, people on the Pine Ridge Indian Reservation live on a third of what the average American earns and are three times as likely to be jobless. They also commit suicide twice as often. In this part of America, whole landscapes seem raw with the memory of what went on here in the late 19th century. This is the land of the Custer campaigns and the Ghost Dance, where Lakota Sioux resisted the coming of the whites and the loss of their sacred lands with every beat of their hearts. Sitting Bull's grave is out here.

Approaching Cheyenne River after sundown, I hit the search button on the radio and landed on the biggest station around—KLND, Indian owned and operated—just in time to catch a dedication. "For all you lovebirds out there, whether you're snaggin', shackin', or married," said the deejay. "Here's Lil' Kim!" If nothing else, young Americans of all colors have music in common: 50 Cent and Eminem are just as popular with Indians as they are with other American kids. Short hair, tattoos, and baggy pants are everywhere you look. Even adult men who used to wear shoulder-length hair have gone to the buzz cut, in a quiet revolt against Indian stereotypes.

A while later, at my motel, I tuned in channel 30 on cable and saw an ad from Emmanuel Red Bear—who also goes by the Lakota name of Tatanka Iyotake, the same name as his great-great-grandfather, Sitting Bull—making it known that he is a certified Lakota language instructor, an experienced emcee for powwows, honorings, and giveaways, and is also available for suicide counseling and gang awareness workshops. It was a vision of hope that made me sit up in my chair.

The next day I caught another glimpse of hope, this time in black and white. On the wall of Dennis Rousseau's office hangs one of those reservation maps I've grown familiar with over the years, showing the checkerboard pattern of lands once reserved for Indians. Today about

LIFE ON THE REZ

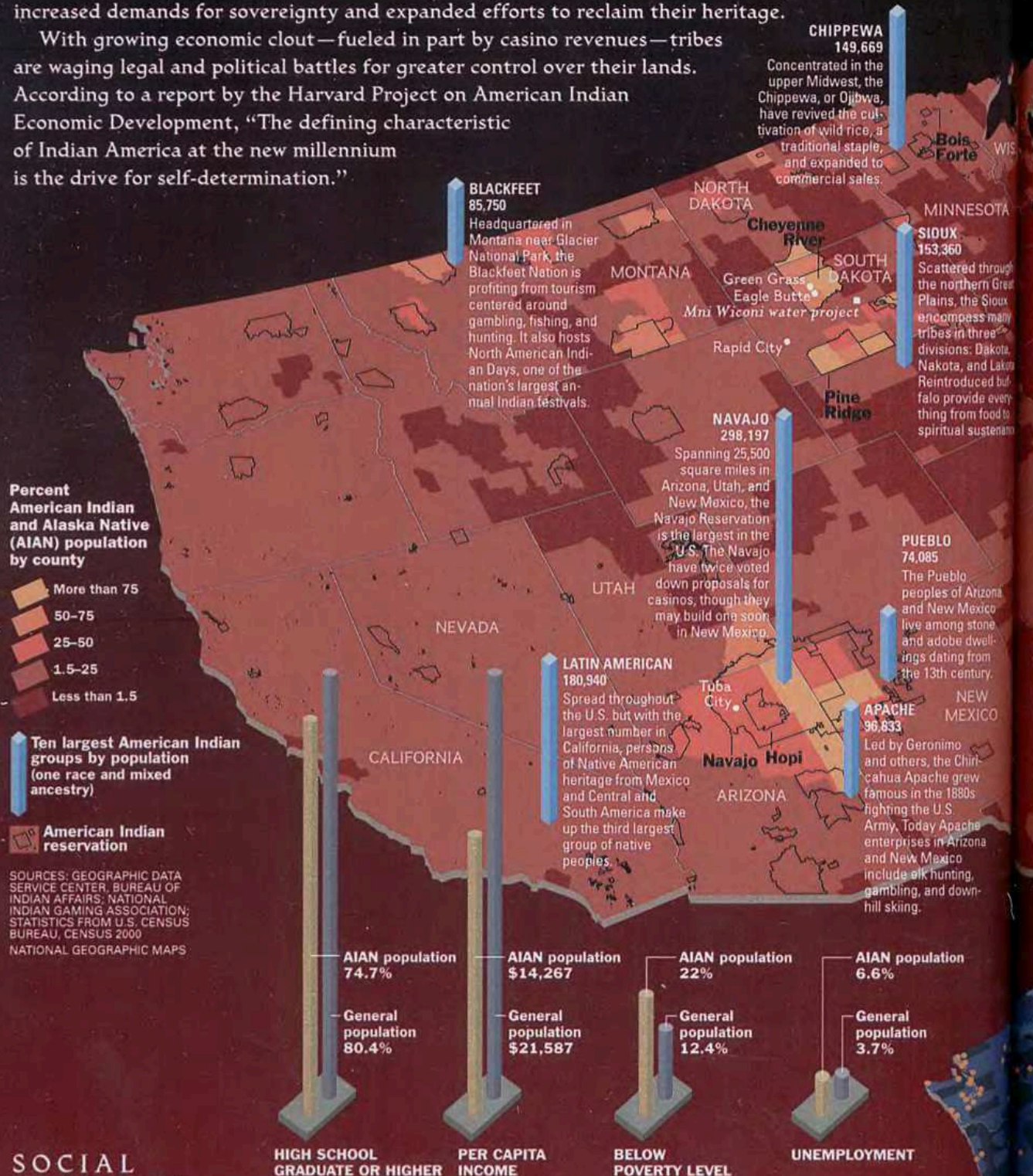
Children get lessons in calf roping as Sunday afternoon winds down in Tuba City, Arizona, on the Navajo Indian Reservation. The reservation, at 25,500 square miles—about the size of West Virginia—is the nation's largest. The Navajo Nation has about 250,000 members, more than half of whom live on the reservation.



Ripples of Renewal

Cultural and economic energy is flowing across Indian Country—in the archipelago of reservations remaining from once vast territories, and in the myriad communities around the nation where Indians have made their homes. This revival was ignited with the political activism of the 1960s when, after centuries of subjugation and government control, Indians increased demands for sovereignty and expanded efforts to reclaim their heritage.

With growing economic clout—fueled in part by casino revenues—tribes are waging legal and political battles for greater control over their lands. According to a report by the Harvard Project on American Indian Economic Development, “The defining characteristic of Indian America at the new millennium is the drive for self-determination.”



SOCIAL SNAPSHOT

For Native Americans, achieving social equality remains an elusive goal. Progress has been hindered by government policies, a lack of productive land, too little capital for development, inadequate health care and education,

poverty, and a fractured sense of identity. The four interrelated social barometers charted here illustrate the challenges, which are more acute on reservations than among Indians living elsewhere. But some hopeful trends

are gaining momentum. In the past two decades Indians have seen an 80 percent jump in post-secondary school enrollment. And between 1990 and 2000 per capita income grew 27 percent on Indian lands.

CHIPPEWA
149,669

Concentrated in the upper Midwest, the Chippewa, or Ojibwa, have revived the cultivation of wild rice, a traditional staple, and expanded to commercial sales.

BLACKFEET
85,750

Headquartered in Montana near Glacier National Park, the Blackfeet Nation is profiting from tourism centered around gambling, fishing, and hunting. It also hosts North American Indian Days, one of the nation's largest annual Indian festivals.

MINNESOTA

SIOUX
153,360

Scattered through the northern Great Plains, the Sioux encompass many tribes in three divisions: Dakota, Nakota, and Lakota. Reintroduced buffalo provide everything from food to spiritual sustenance.

NAVAJO
298,197

Spanning 25,500 square miles in Arizona, Utah, and New Mexico, the Navajo Reservation is the largest in the U.S. The Navajo have twice voted down proposals for casinos, though they may build one soon in New Mexico.

PUEBLO
74,085

The Pueblo peoples of Arizona and New Mexico live among stone and adobe dwellings dating from the 13th century.

LATIN-AMERICAN
180,940

Spread throughout the U.S. but with the largest number in California, persons of Native American heritage from Mexico and Central and South America make up the third largest group of native peoples.

APACHE
96,833

Led by Geronimo and others, the Chiricahua Apache grew famous in the 1880s fighting the U.S. Army. Today Apache enterprises in Arizona and New Mexico include elk hunting, gambling, and downhill skiing.

AIAN population
74.7%

General population
80.4%

AIAN population
\$14,267

General population
\$21,587

AIAN population
22%

General population
12.4%

AIAN population
6.6%

General population
3.7%

HIGH SCHOOL GRADUATE OR HIGHER

PER CAPITA INCOME

BELOW POVERTY LEVEL

UNEMPLOYMENT

CHEROKEE
729,533

Expelled from southeastern homelands in the 1830s, most Cherokee were marched to present-day Oklahoma on the Trail of Tears. Today the largest Cherokee populations are found in Oklahoma, California, Texas, and North Carolina.

IROQUOIS
80,822

Formed before the arrival of Europeans, the Iroquois Confederacy of six Indian nations was governed by a democratic system that may have influenced framers of the U.S. Constitution.

Kanatsiohareke
NEW YORK CONNECTICUT
New York

PENNSYLVANIA
Carlisle Indian Industrial School
Washington, D.C.

WEST VIRGINIA
NORTH CAROLINA

CHOCTAW
158,774

After manufacturing car-stereo speakers and electronics in the 1980s, the Mississippi Choctaw got into the casino business in the '90s. Today the tribe has expanded into high-tech enterprises, producing satellite images and digital maps. Oklahoma claims the largest number of Choctaw.

Tahlequah
Park Hill
OKLAHOMA

TEXAS

CHIPPEWA
(13 casinos)

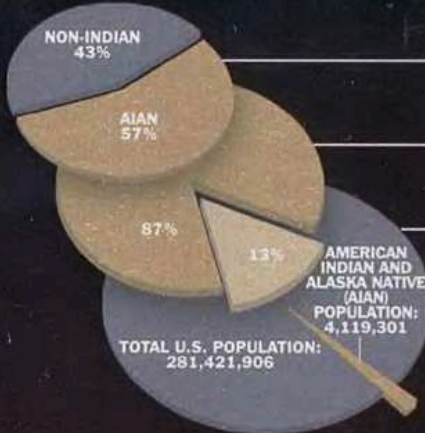
ONEIDA
(5 casinos)

CHEROKEE

CHOCTAW

CONCOW-MAIDU
Feather Falls

APACHE
Hon-Dah
APACHE
Apache Gold



Nearly half the people living on reservations and trust lands are non-Indians.

Only one-eighth of American Indians and Alaska Natives live on reservations.

American Indians make up 1.5 percent of the total population of the United States.

PROFILE OF A PEOPLE

If there is strength in numbers, then Indians are gaining might. The number of Americans who identify themselves as at least part Indian grew from a low of about 240,000 in 1900 to more than four million today (including the 2.5 million who claim American Indian or Alaska Native as their only race). Just a fraction of all Indians live on reservations, the rest having merged into other communities. Land ownership remains a battleground. The confiscation of Indian lands became easier in 1887 with passage of the Dawes Act, which mandated allotment—a system that subdivided tribal lands and granted ownership to individual Indians. Many of those properties were later sold or leased to non-Indians, who now account for nearly half the total reservation population.

Percent American Indian-owned businesses by county, 1997



Indian-owned casino, gaming enterprise, 2003

ECONOMY

Forty percent of the 562 federally recognized tribes have gaming operations—from bingo to casinos—that generate about 15 billion dollars annually. The number of Indian-owned enterprises has risen sharply in such areas as motels, resorts, and manufacturing.

half of the original 2.8-million-acre Cheyenne River reservation is in tribal hands; the rest was expropriated by federal allotment acts between 1887 and 1934 and sold to whites. But the tribe is making a huge investment in its future by seeking a federal loan to buy back 22,140 acres, including the grazing land where their buffalo herd now roams.

With more than 3,000 animals, the Cheyenne River herd is the largest tribally owned buffalo herd in America, and one of the best managed. Tribal biologists, for example, plant microchips in young buffalo to identify and monitor each animal from a command post in Rousseau's office. Some of the animals are sold commercially, but most of the meat, which passes USDA inspection, goes to schools and other tribal programs such as the Elderly Nutrition Center, part of an effort to reintroduce buffalo meat, which is leaner than beef, as a staple of the reservation diet.

Long-term, says Dennis, the goal is to reestablish buffalo culture on the reservation, with benefits both practical and spiritual. "The buffalo, which is sacred, is still providing for us by giving us a paycheck and putting food on the table," said Dennis. "Nature put the buffalo on this Earth for a reason. So I guess it's come full circle."

Full circle. That's an apt metaphor for the state of Native America in September 2004. For more than a century, Indians in the United States survived in the white man's shadow by humbling themselves, becoming invisible, learning to survive, if barely, on handouts from the federal government. Inevitably, the fabric of Indian communities, their dignity and identity, were left as shredded and thin as the few remnant buffalo herds on the Great Plains, ghostly reminders of a rich and glorious past.

Today that situation is changing as Indians across the U.S. exert new influence over their lives and their communities. One of the most visible signs of change is what some call the "new buffalo"—the casino, which for better or worse has become Indian country's most potent symbol of economic empowerment, mostly due to the success, and notoriety, of gaming tribes like the Mashantucket Pequot in Connecticut, whose Foxwoods casino will gross more than a billion dollars this year.

Other tribes have followed the Pequot and opened casinos of their own: Hon-Dah and Apache Gold in Arizona, Feather Falls in California, Cherokee Casino in Oklahoma. Still, only 40 percent of federally recognized tribes run gaming operations, and not all Indian casinos earn substantial income. Even those that do are subject to the oversight of nontribal bureaucracies at both the state and federal levels. Many Indians also question the long-term viability of gaming, which depends, like a fad, on the tastes of a fickle public.

With this uncertain future in mind, the Oneida Nation of Wisconsin has directed casino profits toward tribal development and used them to buy new land, pave roads, and even build an elementary school in the shape of a huge turtle, revered by the Oneida. "A generation ago our children went to school in old clothes and were taunted by the kids who were better off," says Bobbi Webster, the tribe's public relations director. "Today those other kids are jealous."

The Oneida are also diversifying their portfolio. With three other tribes, they founded Four Fires, a business consortium designed to explore opportunities beyond gaming. Their first joint venture is a 43-million-dollar hotel near the National Museum of the American Indian, opening this month in Washington, D.C. Embodying the renaissance in Indian country, this museum, which houses one of the world's largest collections of Indian art and culture, was funded in part by millions of dollars in casino revenues, donated by tribes like the Pequot and Oneida.

The Chippewa of northern Minnesota went a different route, investing half a million dollars of their casino profits to revitalize the mainstay of their traditional life: wild rice, an annual aquatic grass that grows only a few places in the world. One of them, happily, is Nett Lake on the Bois Forte Chippewa reservation—the largest contiguous wild rice lake in the world, where native people have been gathering *manoomin* since the time of the ancestors.

Historically the rice harvest brought this community together, kept it intact, and provided a major source of income. However, in the 1970s and '80s outside growers with new methods drove the price to a fraction of what the Indians were getting. Bois Forte rice production also waned as Nett Lake became overgrown with reeds and other vegetation. That changed in

2003, when the tribal council decided to allow motorized barges and cutting equipment, paid for by casino money, onto the sacred lake to clear out the sedges, bulrushes, and water lilies that had created bogs and choked off the flow of water needed to grow rice.

To see how the restoration was going, I paddled out onto Nett Lake one morning with Ron Boshey and his 32-year-old son, Barry Day. Once we were clear of the shore, Ron pulled a cigarette from his pocket and stripped off the paper. Then he balled the tobacco in his hand and sprinkled it over the water as he spoke a few words of Chippewa.

"Just a little offering to the Great Spirit," he explained. "Asking for a good harvest."

Leaning hard into his pole, Barry sent us cruising silently into the nearest rice bed, which rippled like a wheat field in our passing wake. Then he steered us into a patch where the rice grains were ripe brown. Ron reached out with a pair of slender wooden sticks, called knockers, which he used to strip rice into the bottom of the canoe, moving his arms with the fluid grace of a tai chi master. Soon the canoe was filled with long quills of rice. I noticed other boats moving in the reeds nearby, and I felt as if we'd all hit the jackpot.

I was on a train clattering south along the Hudson River, heading toward a place as Indian as anywhere in the United States: New York City. Famously traded to (or stolen by) the Dutch in 1626, New York today is home to more than 85,000 Native Americans. About 85 percent of Indians in the United States now live off the reservation, and every large city in the U.S. has its own Indian community. This is partly due to a government relocation program, begun in 1952, that sent thousands of Indians around the country in search of work.

Brad Bonaparte is one of these urban Indians, a 42-year-old Mohawk artist and ironworker whose father and grandfather walked the high steel with wrenches and welding torches, making the city's skyline. Every workday he puts on a brown hard hat bearing the insignia of an eagle feather, a potent symbol of blessing and protection worn by many Mohawk ironworkers.

Brad remembers admiring the World Trade Center from his apartment in Jersey City. "I used

to see those towers at night, and always thought how cool it would be to have the job of changing the lightbulbs on the antenna." After the towers came down on 9/11, Brad was one of the many Mohawk who worked to clear the debris and search for remains, putting in 12-hour days for three and a half months. And like everyone else working in the ruins, Brad's crew soon carried burdens heavier than concrete and steel.

"Every kind of priest was there, from the Catholics to the Buddhists, but there was no one for us Indians. One day we heard there was a tobacco burning ceremony a few blocks away, at the New York branch of the National Museum of the American Indian, so we all just walked off the job and went there." It helped. A few days



LONG HAUL

Five times a week, Pearl Bearing hikes to a roadside tank to fetch water on South Dakota's Pine Ridge Reservation. Many Pine Ridge homes have no running water. But a lack of federal funding threatens completion of the Mni Wiconi project, which is bringing Missouri River water to eleven counties and three reservations.

later Brad's crew found the radio tower he'd dreamed about. "I ended up standing on it," he says, "but not in the way I thought."

For Brad and many thousands of other Indians, Native identity is a growing source of strength that helps them cope with the mainstream America that flows all around them. Yet it can also be a source of turmoil. I speak from personal experience: Like many Native Americans today, my heritage is mixed. My mother was Abenaki, my father was Slovak, and it didn't really dawn on me that I was Indian until I was

in my teens. Even then, it took a long time for my own mother to accept that I was the first of my family in three generations to go “public,” to seek out relatives and elders who could teach me the stories and language my Abenaki grandfather never shared with me. For a while my mother referred to me as, “My son, the Indian,” until my younger sister Margaret asked, “But Mom, what does that make you and me?”

Good question. Such confusion, often laced with self-hatred, is surprisingly widespread, even in communities where Native blood predominates. “Are you proud to be Lakota?” I heard a Sioux man ask a six-year-old on Pine Ridge Reservation, in South Dakota. “Nuh-uh, I’m not an Indian,” the little boy said before running away.

That anxiety, like so much that impedes Native Americans, is a legacy of U.S. government policies. For half a century the tone of Indian education was set by government boarding schools such as the Carlisle Indian Industrial School in Pennsylvania, founded in 1879 by Richard Henry Pratt, a U.S. Army officer whose philosophy was “Kill the Indian and save the man.” Schools like Carlisle removed Indian kids from their families at an early age; some were kept until they were adults. If they spoke their native languages, they were severely punished. No wonder, then, that today surprisingly few Indians speak their native tongue or know much about their own traditional culture.

Tom Porter is an elder of the Mohawk Nation living in upstate New York whose grandfather and great-grandfather both attended the Carlisle School. He remembers the gray-faced men he knew as a child: “When they came home, they were just like a computer that has no feelings.” He never heard his grandfather speak a word of Mohawk, one of the Iroquoian languages.

By 1997 about 5 percent of Iroquois still spoke their native tongue; of those, most speakers were in their 70s and 80s. Concerned that the Mohawk were on the verge of losing their language altogether, Porter initiated what he calls a “Carlisle School in reverse” to jump-start his own personal Indian renaissance in a new Mohawk community. Called Kanatsiohareke

(meaning “place of the clean pot”), Porter’s community offers several two-week immersion courses in Mohawk language each summer, taught by fluent speakers.

The results, though modest, are measurable. Forty or more students take the courses every summer, including several dozen or so who have become fluent enough in Mohawk to speak at ceremonial occasions. One day as I watched a language class, I noticed that one of the instructors, Bonnie Jane Maracle—whose Indian name is Iehnhontokwas—looked younger than most of her students. “I’m one of the 2002 graduates,” she said, beaming. “A few years ago I could barely talk Mohawk, but now I’ve learned enough to teach the Mohawk phonics class.”

The Cherokee Nation, with tribal headquarters in Tahlequah, Oklahoma, also offers language immersion classes to help preserve Cherokee culture. The courses are based on a syllabus developed by the Cherokee’s peripatetic genius, Sequoyah, in the early 19th century that helped the Cherokee to become the most literate of Indian nations, with its own newspapers and schools. The Cherokee also developed political skills that they sharpened in the 1830s, as leaders such as Chief John Ross lobbied Congress, in vain, against the forced removal of 16,000 Cherokee from tribal homelands in the southeast U.S., culminating in the infamous Trail of Tears.

Today, in a clear sign of renewal, the Cherokee are again showing their gift for cultural and political sophistication—a balance of tradition and practicality that has helped them endure the near-death experience of their expulsion to Oklahoma, the periodic landgrabs and neglect of the U.S. government, and a litany of other injustices, from a lack of potable water to anti-Indian demagoguery in Congress.

Led by Principal Chief Chad Smith, the Cherokee Nation runs a dynamic lobbying program, with a full-time office in Washington that deals with government’s convoluted bureaucracies—ranging from Congress, which writes the federal laws governing relations with Indian tribes, to the Bureau of Indian Affairs, which administers U.S. policy. Smith himself spends a lot of time in Washington calling on legislators and federal agencies, and notes that the American Indian experience seems to run

TRIBAL STORYTELLER and author Joseph Bruchac relates the Lakota story of the buffalo, a Chippewa story of migration, and more about his Abenaki heritage. Also see more of Maggie Steber’s photos at nationalgeographic.com/magazine/0409.

in cycles—"adversity, survival, adaptation, and occasional prosperity—over and over."

At the moment, the cycle tends toward adversity. Some powerful lawmakers, focused on casinos, seem to think that every Indian in the country is getting rich—even the Oklahoma Cherokee, who earn just 3 percent of their income from bingo parlors and casinos, or the Hopi, who have shied away from gaming. The Bush Administration proposes to cut more than 100 million dollars from federal Indian programs in 2005, which means that health clinics across Indian country will close on the weekends and jobs will be harder to find.

"People always think Indians are trying to get away with something," Smith observes—especially when Indians have something that others want. The Trail of Tears began, he says, with "the discovery of gold on our lands." He chuckles. "And now one of our biggest assets is casino gold. It's all part of the cycle."

Alarmed by the mood in Congress and attacks on Indian sovereignty, 115 members of the House of Representatives have joined the Congressional Native American Caucus, a bipartisan group that represents tribal interests on Capitol Hill. And the National Congress of American Indians is mounting a national grassroots campaign to turn out a million Indian voters in November.

"Everything that happens in Congress directly affects the lives of our people, which is why we're fighting so hard to be heard," says Kimberly Teehee, a Cherokee who works as senior adviser to the caucus. "Indians have more political muscle than people realize."

I looked for signs of Indian renewal all over this country, and I found them, but I kept coming back to buffalo. One buffalo in particular. I saw him only once, in South Dakota months ago, but he's with me still, like a recurring dream.

Dennis Rousseau and I were out in Sioux country, where Sitting Bull led his band of survivors toward a vision that only he could see. Just before sunset Dennis and I decided to drive out in search of the buffalo herd one more time, just for the fun of it.

As soon as we left the main road, we were surrounded by prairie dogs. Their burrows dotted the landscape on both sides of us, their quick whistles raised the alarm from hill to hill.

A round head poked up out of one burrow, swiveled toward us, ducked out of sight. A burrowing owl materialized, followed by the wide wings of a ferruginous hawk. Both were hunting for prairie dogs. The hawk passed; a meadowlark popped up from the grass and flew in the opposite direction. It was as if I'd traveled back 200 years, to a time before the slaughter, the plows, the heavy hooves of cattle.

Then a wind kicked up, blowing dust across the grass. For a moment the land looked like a yellow ocean rippled by waves.

Dennis nodded. "The buffalo will be coming down here into that wind," he said.

"Facing into the storm?"

"Cattle," Dennis said, "just let the storm push



STANDING FAST

"We don't want money, we want land," says Nick Tilsen, at right. An 1868 treaty preserved the Black Hills for the Lakota, but the U.S. government took the land anyway. In 1980 the U.S. Supreme Court upheld the Lakota claim, offering financial compensation—but no land.

them. But not buffalo. They know there's an end to the storm, so they go into it."

"Like Sitting Bull did," I said.

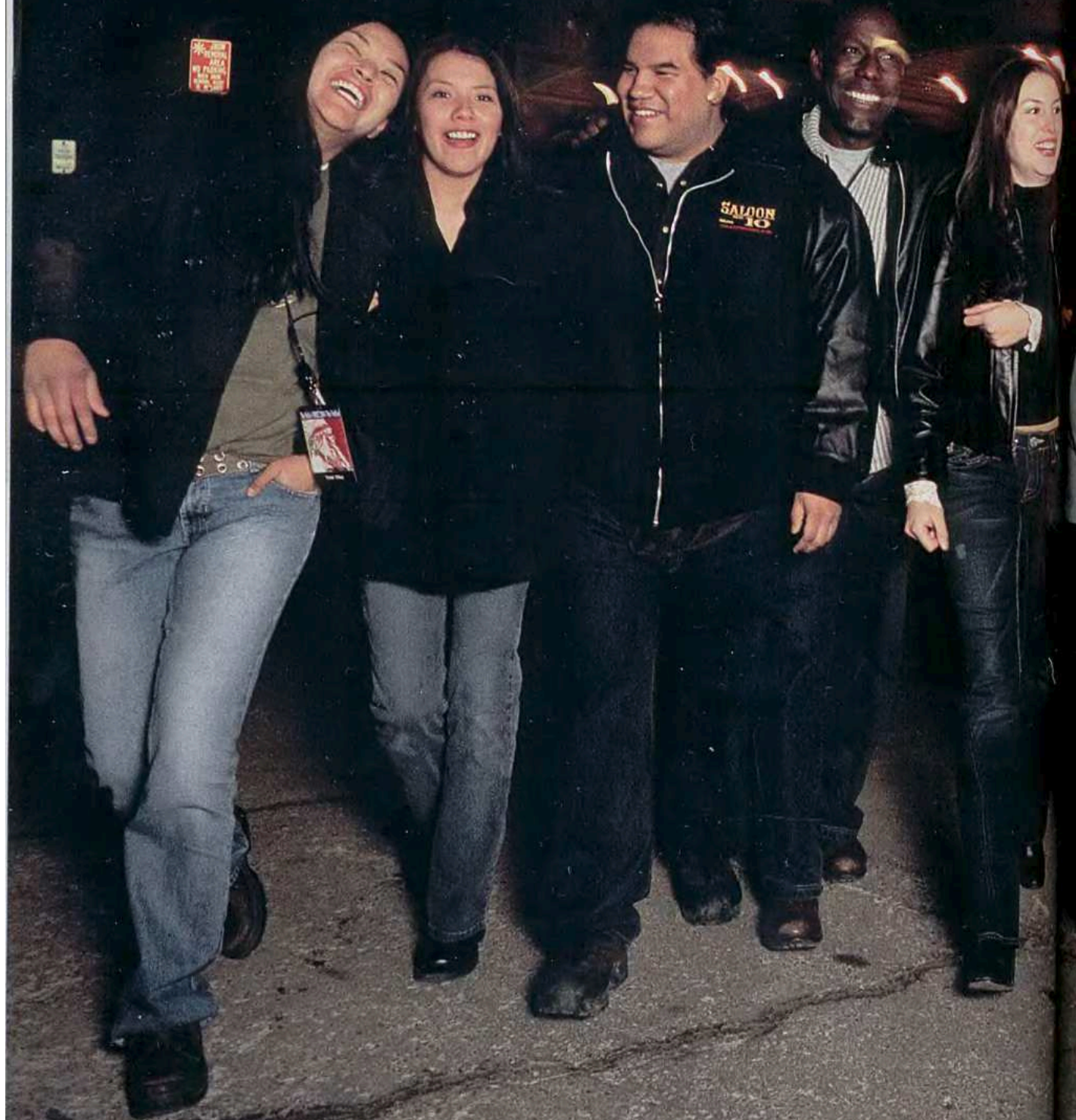
"That's right," Dennis said. "That's right."

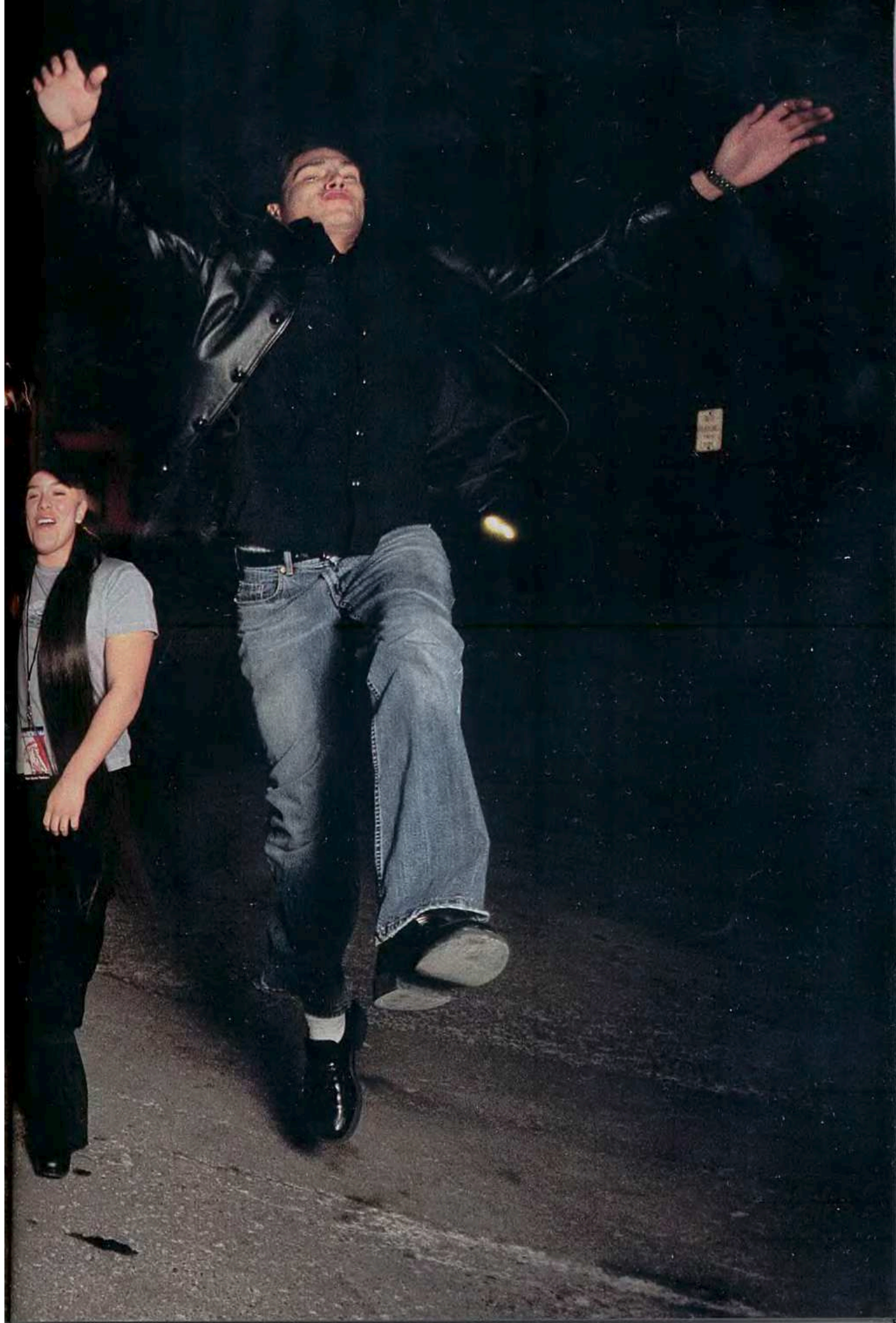
Soon we saw a solitary bull, head down, pushing forward against the weight of the wind. We followed him over a small rise and found ourselves in the midst of hundreds of buffalo. Young bulls, calves, yearlings, cows. They were peaceful and fully alive, charged with a power that seemed to flow from the old, enduring earth itself. Dennis took this in, gave me a look.

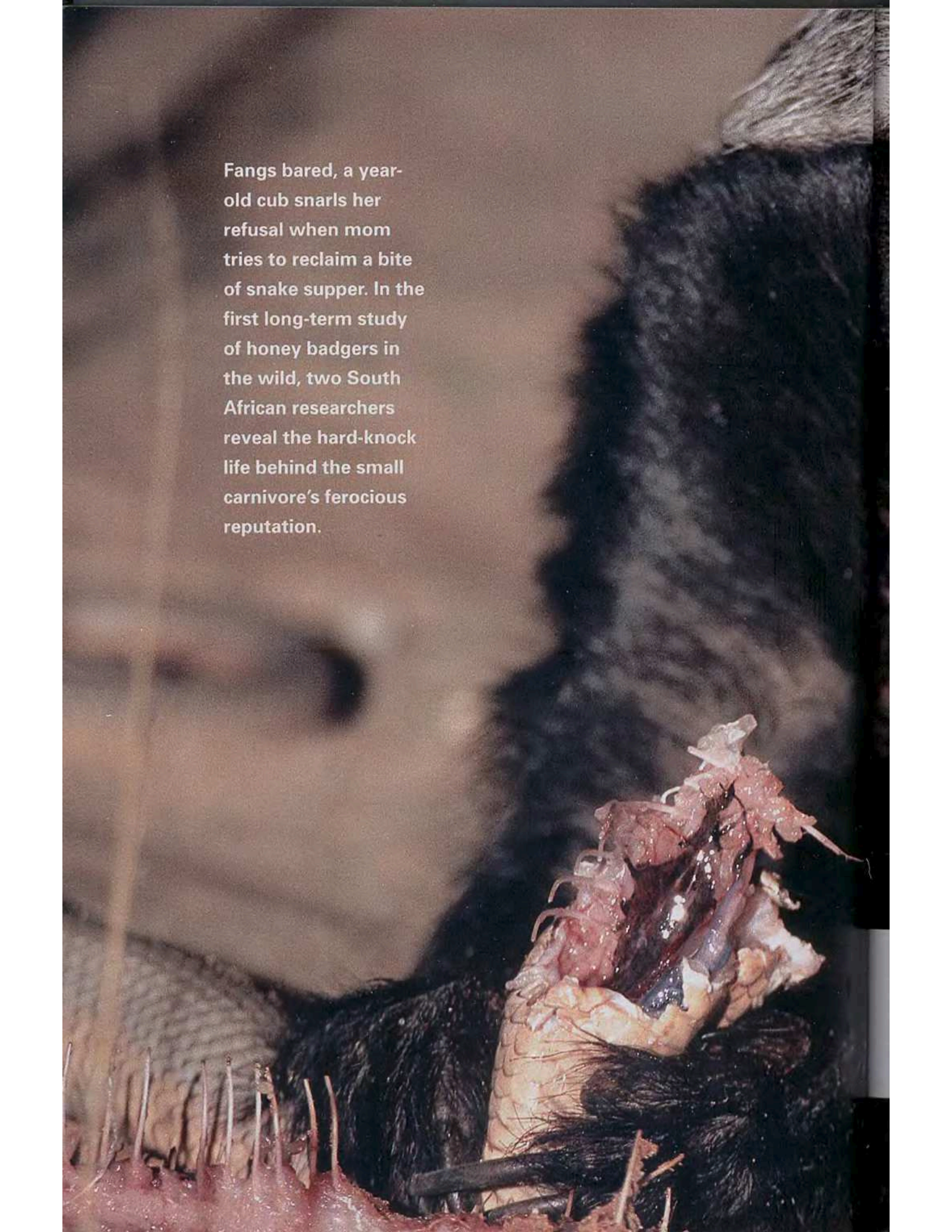
"The wonders," he said, "of buffalo."

RAVE REVIEWS

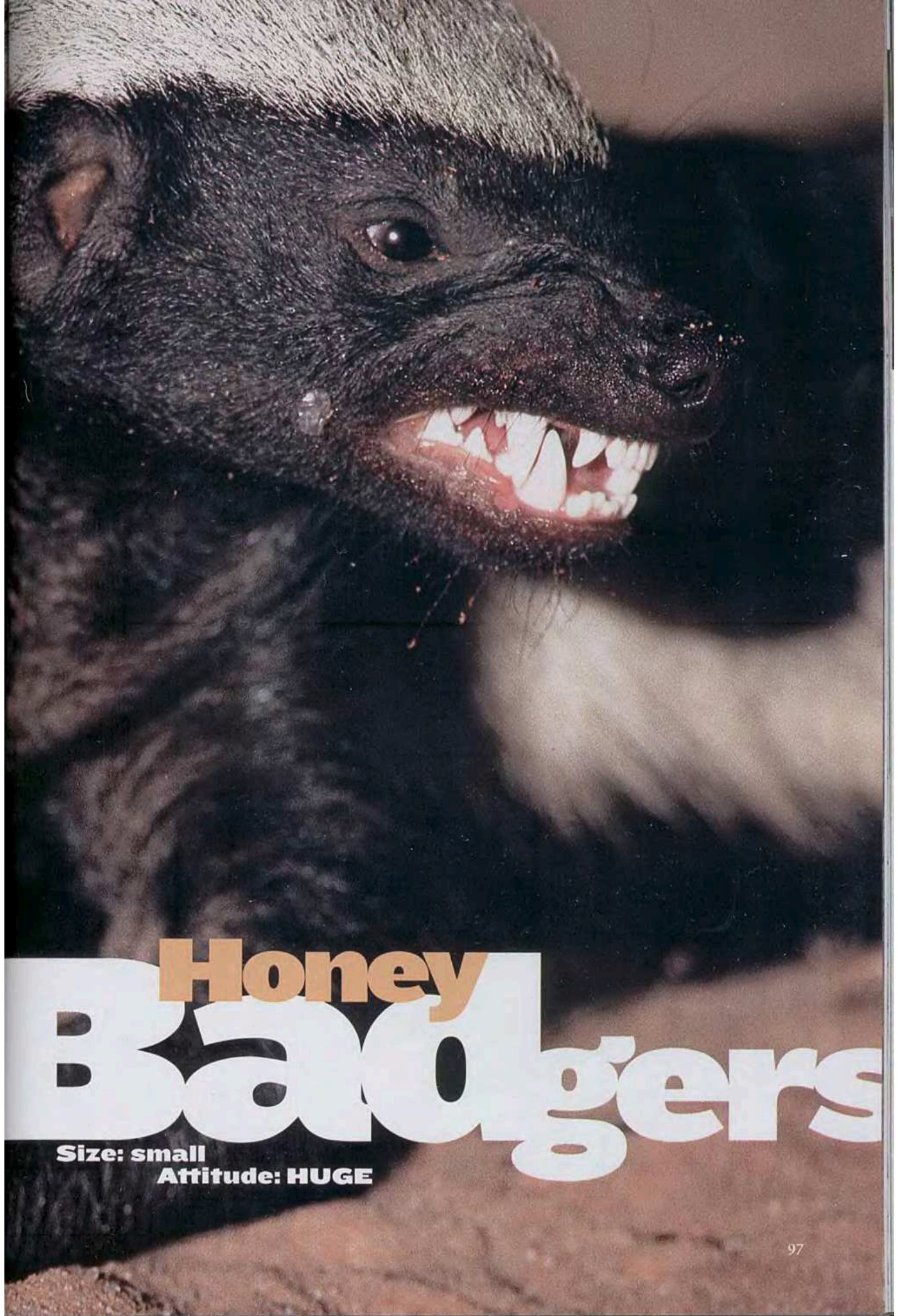
Cast members savor success after their movie, *Edge of America*, played to an enthusiastic audience at the 2004 Native Voice film festival in Rapid City, South Dakota. Chris Eyre, third from left, a Cheyenne-Arapaho, directed the film that stars James McDaniel, center, as an African-American teacher who coaches a girls basketball team at a reservation high school. In the end, he learns more from the girls than they do from him—about overcoming differences and learning to respect yourself and others. It's not whether you win or lose, says Eyre, "but how you represent yourself and your community." □







Fangs bared, a year-old cub snarls her refusal when mom tries to reclaim a bite of snake supper. In the first long-term study of honey badgers in the wild, two South African researchers reveal the hard-knock life behind the small carnivore's ferocious reputation.



Honey
Badgers

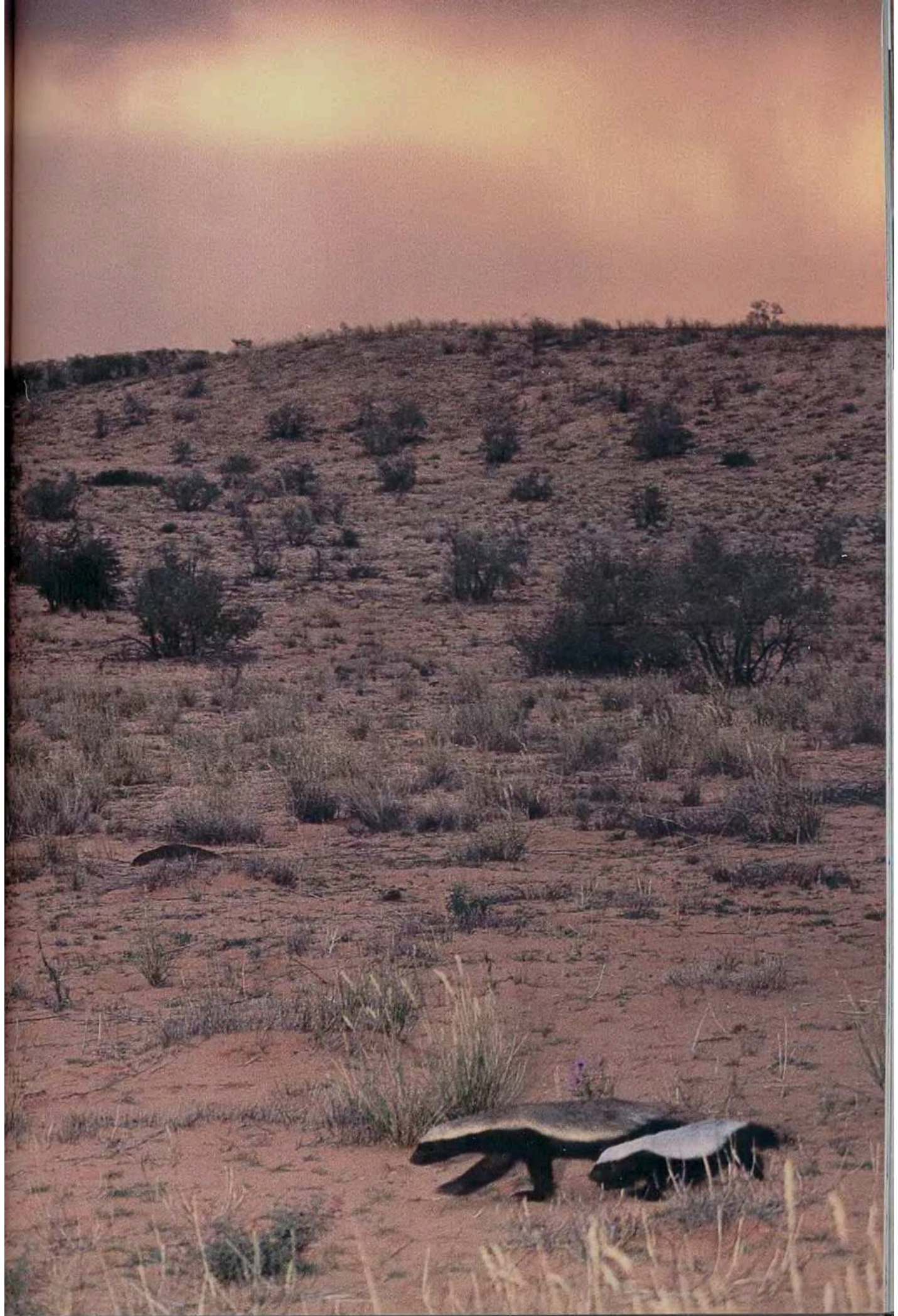
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**Text and photographs
by Colleen and Keith Begg**

As the Kalahari Desert cools at twilight, a honey badger and her cub begin foraging for food—two of dozens of badgers whose habits we documented over nearly four years. Supported by the University of Pretoria's Mammal Research Institute and the Endangered Wildlife Trust, we established a 600-square-mile study area in the Kgalagadi Transfrontier Park (jointly managed by South Africa and Botswana) and spent nearly 6,000 hours there observing wild badger behavior. We saw them confront enemies, mate, rear young, and hunt prey from insects to reptiles and rodents.

Honey badgers are famously tough. (South Africa's National Defense Force calls its armored personnel carriers *ratels*, the Afrikaans word for these beasts.) But we discovered that they're far from indestructible. Lions and leopards routinely kill them. The badgers' appetite for ravaging beehives (thus their common name) causes conflicts with commercial honey producers, some of whom shoot, trap, or poison animals they suspect of damaging their hives. Females have just one offspring at a time—not the multicub litters previously assumed—and though they care for their young for more than a year after birth, half of all cubs succumb to predators or starvation and die before achieving independence.

DESERT TOUGHS Watch video of these critters in action, and find more honey badger stories, photographs, and links to resources that can help you learn about these rough-and-tumble survivors at nationalgeographic.com/magazine/0409.



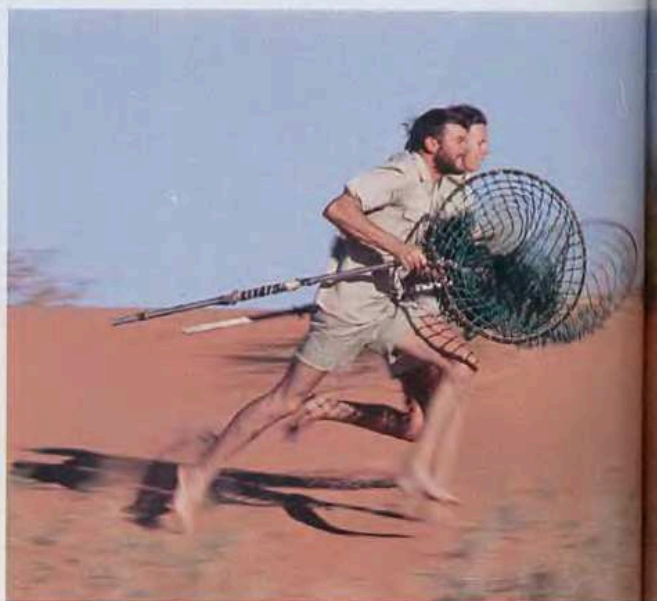


Hide and seek—on a grand scale

Shoes make it harder to run in soft sand, so we do most of our badger tracking barefoot (right). Scorching heat and thorny brush are minor concerns when you're trying to net a 25-pound male that easily trots at six miles an hour and patrols a home range of 200 square miles or more. (A male North American badger of about the same body size

has a home range of only one square mile.) Female honey badgers are smaller, averaging under 15 pounds, yet even they cover upwards of 50 square miles as they forage and rear their young.

A mother carries a tiny cub, like the two-month-old above, more than a mile to a new den every three to five days. Once the cub



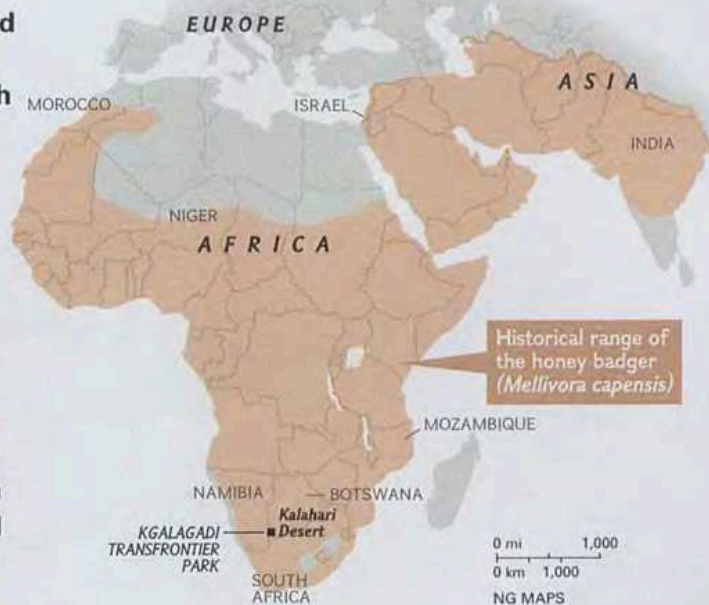
CAROL HUGHES

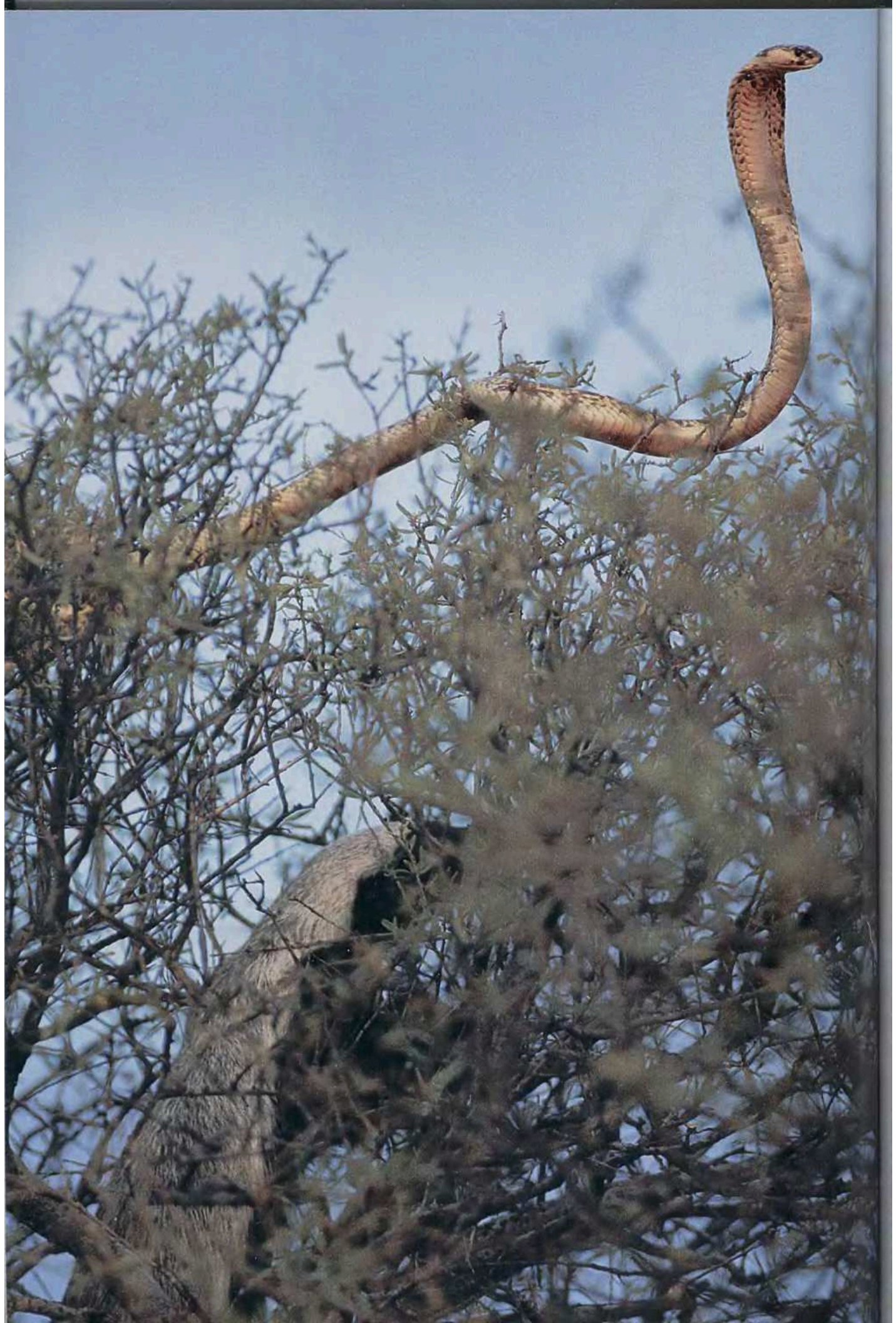


can walk well on its own, the mother and cub will sleep in a different burrow almost every night to evade predators and find new prey.

Little is known about honey badger numbers in most countries where they're found (map), but they seem to be disappearing in many areas. They're considered endangered in Niger, protected in

Israel and India, and near-threatened in Morocco and South Africa. We're worried about them. Their need for large ranges, combined with low reproductive rates and human persecution, may mean that many national parks and other conservation areas are too small to protect sustainable populations.







Deadly venom? Maybe not.

Snakes make high-yield meals, and honey badgers track them relentlessly. Wherever snakes try to hide—up trees, in dense brush, or underground—badgers follow and attack. A 13-minute treetop battle with a venomous Cape cobra (left) earned this female badger a pound and a half of meat for herself and her cub. In summer, when

snakes are most active, they provide more than half the total food badgers consume. Even lethal puff adders (above) are on the menu.

One night we saw a young male collapse (right). He'd been struck in the face by a puff adder just before he bit its head off. We expected that he would die. But after two hours he woke up, groggily



finished his meal, and later trotted off into the sunrise. We witnessed other encounters in which honey badgers

appeared resistant to even the most potent venoms, though we don't yet understand the physiology that protects them.



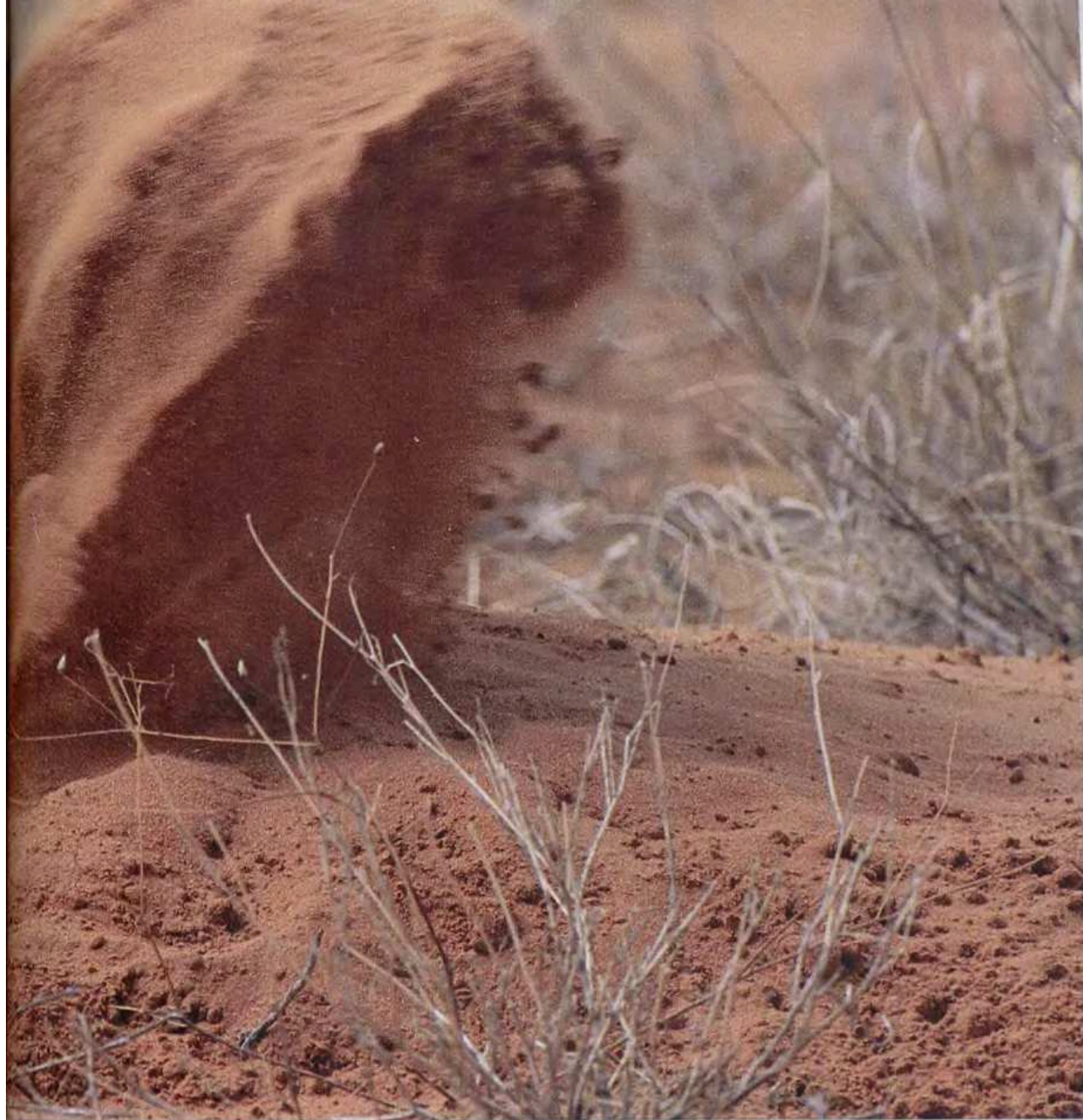
Digging for dinner, then playing it cool



Equipped with inch-and-a-half-long claws that grow throughout their lives, adult honey badgers can dig themselves out of sight in just a couple of minutes (above). They capture more than three-fourths of their prey underground.

Cubs try to dig on their earliest outings, but not until about eight months old do they become adept enough to help their mothers hunt.

Badgers of all ages display a knack for finding refreshment. About 90 percent liquid, the flesh of a



CAROL HUGHES

tsama melon (left) provides needed moisture in a landscape where surface water is nearly nonexistent. If nighttime foraging proves successful, well-fed badgers often pause for a belly-to-the-breeze respite (right), catching updrafts on the dune slopes and flicking cool sand onto hot skin.



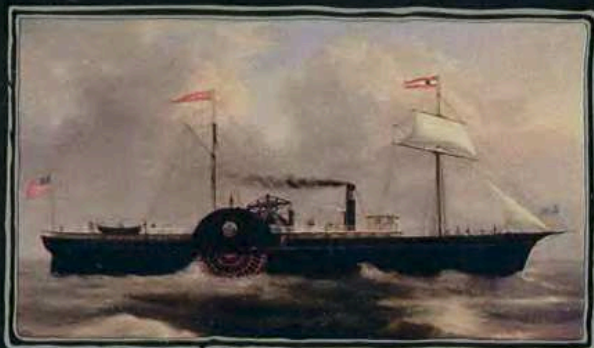


Oppportunists like this goshawk may snatch prey that elude badgers' claws. Freeloaders annoy honey badgers, but

A close-up photograph of a honey badger resting on a log. The badger's body is dark brown, and its neck and chest are a lighter, greyish-brown color. It is lying on its side, facing left. The background is a dry, reddish-brown landscape with sparse, low-lying vegetation. The lighting is bright, casting shadows on the log and the ground.

don't cause them to go hungry. Our next research site? A woodland in Mozambique, where we can watch these two-toned ruffians take on a different habitat. □

CAROL HUGHES



LOST GOLD

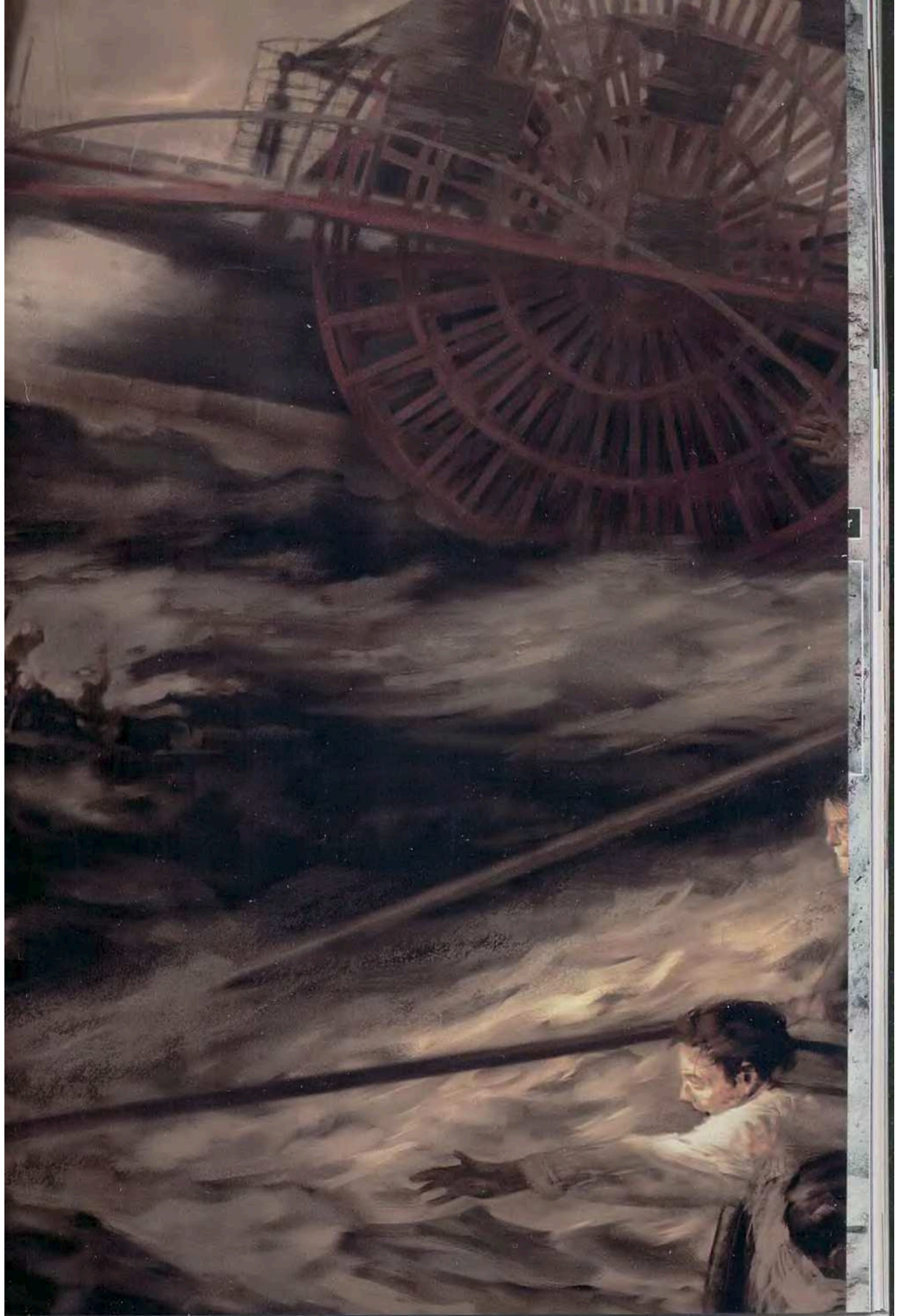
Bounty From a Civil War Ship

Bound from New York to New Orleans in 1865, the *S.S. Republic* sank in a hurricane, sending an emporium of goods—and a hoard of gold and silver coins—to the bottom of the Atlantic.

Now she's been found, and her treasure is worth millions.



Exhausted and desperate after abandoning ship, men in a lifeboat strain to reach others on a makeshift raft. They failed. "The wind was howling... like demons of the sea," wrote lifeboat survivor William Nichols. Of 92 people who boarded Republic, 25 perished—including 12 of the raft's 14 passengers.





ART BY JON FOSTER



The ship's contents reveal American needs and desires on the eve of Reconstruction. Bolts of fine blue fabric [left] and buttons were likely destined for fashionable shops in New Orleans.

The stuff of daily life was strewn across the seafloor.



Popular worldwide, Holloway's Ointment [above] claimed to "cure anything." Bottled berries [left], chamber pots, and dishes [bottom left], as well as inkwells, slates, shoes, and telescopes also filled the hold.



A mosaic of some 800 digital images [facing pages] shows the upright paddle wheels and scattered debris of the S.S. Republic 1,700 feet below the surface. The excavation crew views the wreck through the cameras of Zeus, a remotely operated vehicle [ROV] whose images can pinpoint objects smaller than a thimble.



First christened the S.S. Tennessee, this ship served North and South in the Civil War. The letters SSEE on her bell [above, with new rope] confirmed her identity.



JAR (TOP) AND BELL (ABOVE): PRISCILLA A. SMITH, OME. MOSAIC (RIGHT): OME





Paddle wheel

Religious artifacts

Fabric

Boiler

Ceramics

Paddle wheel



Bottles

Rudder



By *PRIT J. VESILIND*

Photographs by *JONATHAN BLAIR*
ODYSSEY MARINE EXPLORATION

IT WAS A TIME TO MOVE ON, to douse the fires and lick the wounds. The Civil War had ended in May, and the holy quiet that followed had evolved into a vibrant summer hum of opportunity. The defeated South lay poor and bitter, but the rest of the nation had turned, gratefully, back to making money.

In October William T. Nichols, a former colonel of a Vermont regiment, and his younger brother, Henry, put down 60 dollars each and stepped off a Manhattan pier onto the S.S. *Republic*, a steamship bound for New Orleans. They found stateroom number 13, stowed their baggage, and awaited the 3:30 cast off. The weather was heavy outside the harbor, so the steamship lay over until the next morning at Staten Island and embarked again at 9 a.m. on October 19.

Newly refitted from a warship back into a civilian steamer, her twin side paddle wheels turned by coal-fired boilers, the *Republic* carried 59 passengers, 500 barrels of freight, and a reported 400,000 dollars in coins. Hard money was scarce in the former Confederate states, and New Orleans was broke, so bankers and businessmen were shipping keg-loads of coins to take advantage of their inflated purchasing power. In New Orleans the same 20-dollar gold coin would buy twice as much as it would in New York.

Aboard the *Republic* were families with children, Army officers headed for new assignments, and businessmen like Nichols. Dressed in top hats and silk, the passengers breathed the warm salt air, played cards, and drank wine, happy to have survived the war.

Fate had not been kind to William Nichols, a 35-year-old veteran of the Battle of Gettysburg. He had just lost his daughter, May, to typhoid fever. He had also lost a small fortune in stock and wool investments. Now he was looking to the South to regain his footing, planning to continue from New Orleans to Texas, where he hoped to purchase real estate on the cheap. He took heart from the voyage. "The weather is beautiful, and the ship bounds on her way like a thing of life," he wrote to his wife, Thyrza, back in Rutland.

The *Republic* passed Cape Hatteras on Sunday, October 22, and by the next evening the wind had stiffened into a northeast gale. The ship was off the Georgia coast when the gale turned into what the captain, Edward Young, described as the "perfect hurricane." Steaming south at a furious rate, Young could not outrun it.

The end began with a table-clearing roll on Monday afternoon that sent dinner—pies, meats, vegetables, and condiments—tumbling to the floor. The ship labored as towering waves rushed across her decks. The soaked passengers huddled in their berths, sleepless,



PRISCILLA A. SMITH

"We suffered everything but death," wrote William Nichols [right] to his wife, Thyrza, after the disaster at sea. Parched before his rescue, he had sucked on a chain to moisten his mouth. Thyrza [above, in a family heirloom] died of typhoid before seeing her husband again.

Charleston S.C. Oct 30, 1865.

Dear Thyrza

We were shipwrecked on
the Republic somewhere in the
Gulf Stream and something like
150 or 200 miles from the Coast.
We suffered everything but death
but thanks to God, arrived here
this morning safe. Having lost
all our clothing & baggage. In fact



except the clothes we
to have on — We have
— I cannot write you
as we are about to
go for N.O. — Will give
particulars as soon as
I can — Telegraphed
as soon as I got here
Henry & I are well — With love
with much love to all I am

Yours —

William



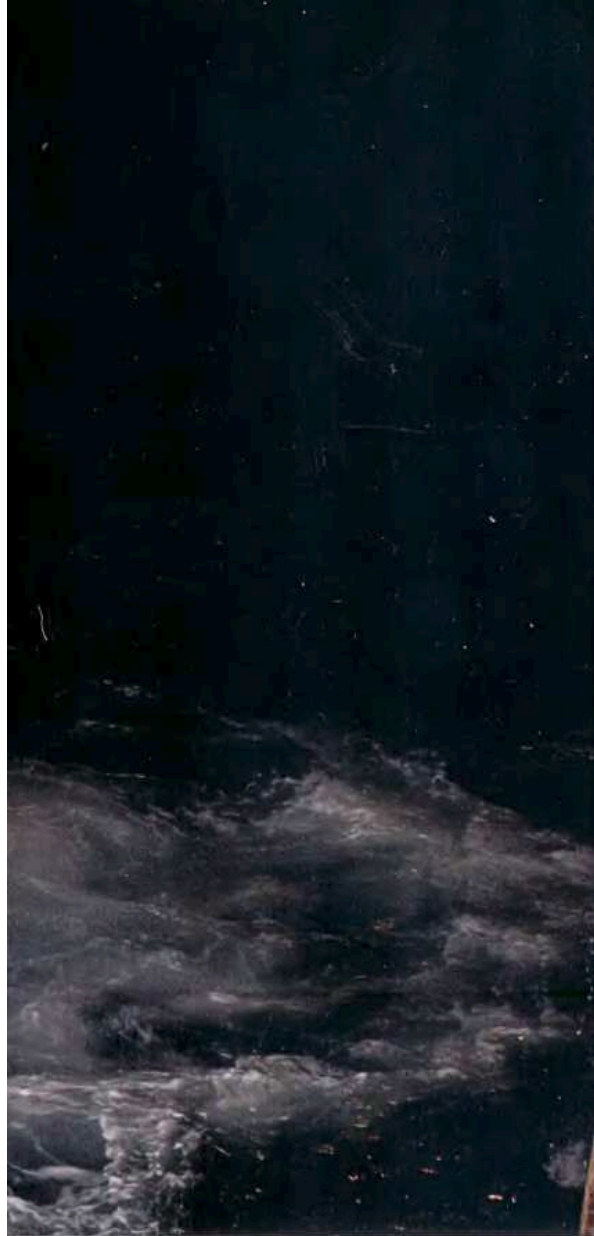
The site demanded industrial-strength gear

and in the nightmare clarity of Tuesday morning they saw the great paddle wheels stop, leaving the piston locked dead center and the ship adrift, at the mercy of the wind. Waves washed away the pilothouse and paddle-wheel boxes. Passengers and crew alike tossed cargo overboard to lighten the ship. Out went bolts of silk, ingots of tin, liquors, tobacco, varnish, and other heavy goods.

"I supposed I had seen something like confusion in battle," Nichols later wrote, "but the scene at this time was sublime. The ship had 300 tons of coal, and as she lurched from side to side, the roar of the coal and water sounded like Niagara, and the water on the outside dashing against the ship was another

distinct sound and horrid enough of itself. The wind was howling through the rigging like the demons of the sea, and to make it a perfect hell, the men, excited and yelling to each other, begrimed with black smut and engine grease. It was desperation intensified."

JUST BEFORE 2 p.m. on October 25, Captain Young gave orders to abandon ship. Crew and passengers climbed into four lifeboats and a raft hastily assembled from the ship's spars. The Nichols brothers clambered into lifeboat number 2, the last one lowered. As the *Republic* gave a final shudder and surrendered herself to the deep, the seas were rolling 40 feet high, tossing the lifeboats and dooming efforts



The ROV Zeus emerges from a night dive to the deep. A 7.5-ton workhorse, it serves as eyes, arms, and chief excavator for Odyssey Marine Exploration, the group that found the Republic.



ust to hold steady.

to keep them together. The raft, without oars or sail, soon floated out of sight, helpless flotsam in the fury of the hurricane.

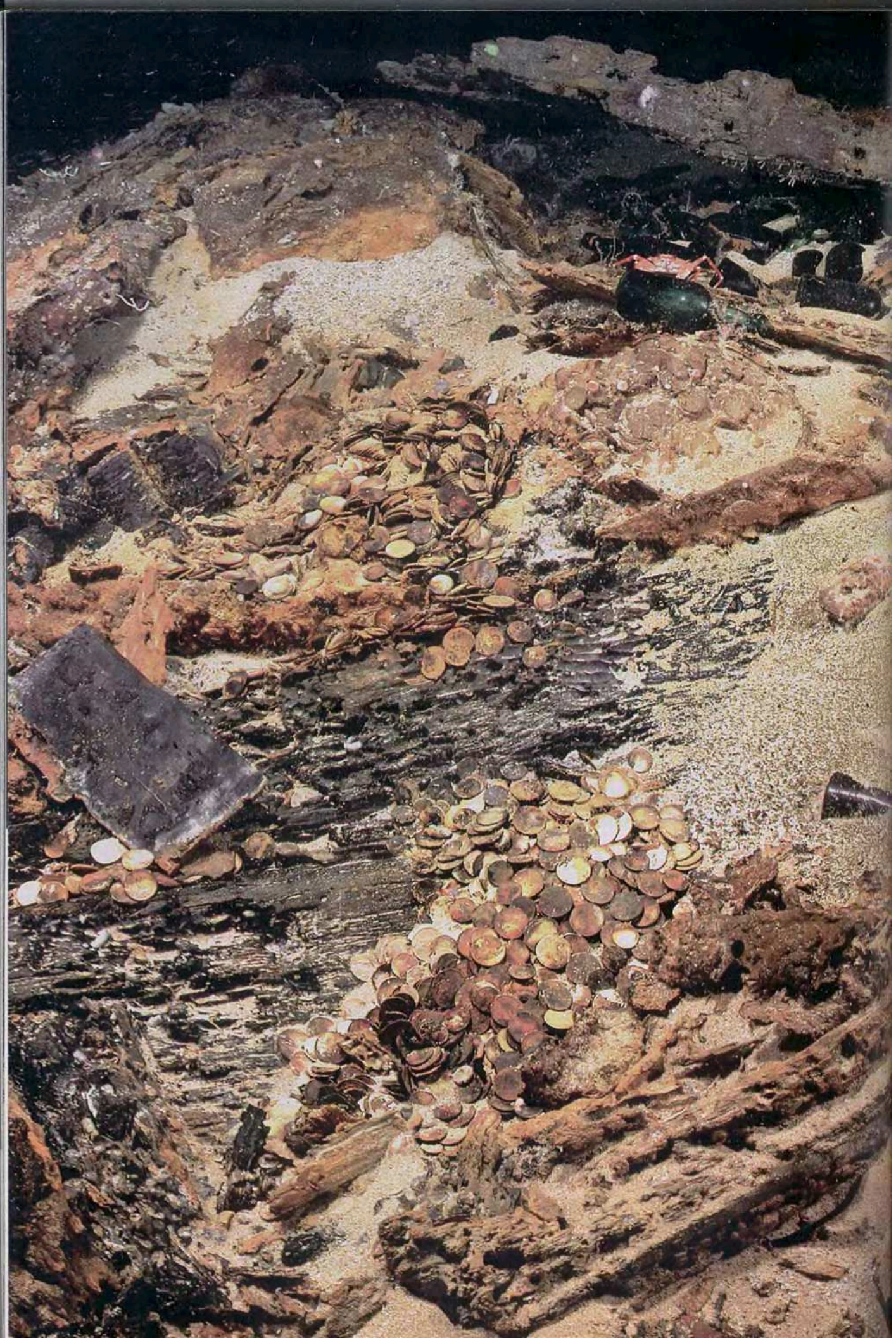
The 15 survivors in lifeboat 2 bailed with shoes and caps to stay afloat and pulled desperately on the oars, enduring a black, cruel night. The next day they rigged up a tablecloth as a small sail. "Thirst, more terrible than anything else I ever suffered, was added to our other calamities," Nichols wrote. "We had not one drop of water, and with all the labor we had performed it seemed impossible to live."

Friday, October 27, dawned with little hope. The survivors' throats began to swell from thirst, and Nichols put his deceased daughter May's gold chain and locket in his mouth to

Crewmen first located the wreck with side-scan sonar and a lightweight ROV about a hundred miles southeast of Savannah, Georgia. Needing a beefier vehicle to toil in the swift current, they brought in Zeus, then equipped it with a camera to transmit images to monitors [above] and manipulator arms to retrieve artifacts. Some gear is rather low-tech:

Odyssey co-founder Greg Stemm [top, right] and Roy Truman turn a soup pot into a carpet-lined container to bring up precious coins.





keep his tongue moist. When a sail came into sight, they thrashed toward it with fury, but it faded away. On the edge of despair, they took off their clothes and jumped into the sea, hoping to absorb some moisture.

And then came another sail. Though fatigued to the point of numbness, they pulled for more than an hour before they got the attention of Captain Joseph Blankenship of the *Horace Beals*. They were not able to stand up when pulled onto the deck of the schooner, but by Monday they were safe in Charleston port. The other three lifeboats also passed through harrowing days and were delivered by passing ships and search vessels.

"We suffered everything but death," Nichols wrote to Thyrza, "but thanks to God, arrived here this morning safe. Lost all our clothes and baggage in fact everything except the clothes we happened to have on—we have our money—I cannot write you but a note as we are about to take the train for New Orleans."

Those on the raft weren't as lucky. Adrift for eight days, all but two of 14 souls were washed off one by one, or simply leaped into the Atlantic in despair. The two survivors—the ship's quartermaster Oliver Martin and waiter James Noolan—were still clinging to the spars on November 2 when the Navy steamer *Tioga* spotted them bobbing south of the Cape Hatteras lighthouse. They had drifted some 250 miles north, riding the mighty Gulf Stream.

2003

ERNIE TAPANES puffed a hefty cigar and gripped the railing of the teetering 113-foot-long research vessel *Odyssey*. It was July off the coast of Georgia, the sea roiling with a mix of thunderstorms, sweltering heat, and six-foot swells. Tapanes, 35, was both investor and oceanic engineer at Odyssey Marine Exploration, based in Tampa, and the operations chief of the ship. In the company's latest effort to find the remains of the *Republic*, he and a crew of ten had been at sea for two weeks. *Odyssey* had heard of at least two other groups planning expeditions to search for the *Republic*. To deflect interest, the team was using the code name *Bavaria* for the steamship.

Finding the *Republic* would vindicate a tenacious 12-year research effort for Odyssey co-founders Greg Stemm and John Morris,



Worth its weight in gold? Far more. Minted from 1838 to 1865, the ten- and twenty-dollar gold pieces [shown in mosaic at left], represent one of the largest, most diverse coin boards ever found. One unique coin may sell for as much as \$450,000. After conservators clean off contaminants [above], graders give coins a number based on condition and rarity. The grade helps determine a coin's price—and so do collection techniques. A dent, a fingerprint, even a claw scratch from a curious crab during the transfer into Zeus's receptacle [below] can lower a coin's value.



Tampa entrepreneurs who were convinced that deepwater shipwreck recovery, despite its many difficulties, could be a viable business venture. The coins that went down in the *Republic* would now be worth much, much more than their face value.

Odyssey researchers had fed an amalgam of wind speeds, currents, bearings from ships' logs, newspaper reports, survivors' accounts, and lifeboat coordinates into computer models. Their crews had combed 1,500 square miles of ocean with side-scan sonar and a magnetometer and examined 24 promising targets. In the past two years alone they'd found a fighter jet, a custom sailboat, and a 19th-century merchant vessel filled with English pottery and Chinese porcelain. But the *Republic* had evaded them.

Ernie Tapanes was a true believer in the mission, but it was wearing him down. He and the team had covered all but the last section—the northernmost square of the search area. "With all the endless days, sticking to your guns, rolling out of bed every morning," he said, "you start questioning—do we have our information wrong? Is the ship findable?"

On July 7, with supplies dwindling and attention wandering, a blocky shape formed on the screen. "It's just a sailboat," said J. J. Jackson, one of the sonar crew. But sailboats are narrower, thought Tapanes, as he finished the survey block and took the ship back to Charleston for fuel and supplies, the sonar image rattling around his mind.

Odyssey badly needed a score—a quick infusion of success. Year after empty year, Stemm and his partner John Morris had been forced to dilute their ownership in the publicly traded company, selling shares until they were only minority holders.

"I know the shipwreck's out there," said Stemm, an intense 47-year-old with a quick, ingratiating smile. "Somewhere on this chart. I know it's there. We just have to stick it out." The company wouldn't go broke as long as loyal investors hung on, but the boys from Tampa were stretching their credibility. "This is painful," said Stemm. "It's just painful."

Using a higher resolution setting on the sonar, Ernie Tapanes and the *Odyssey* crew returned to sea for a better look at the sailboat-like object. They spent two arduous days,

zeroing in on its shape, creating a three-dimensional sonar form. "I've never had an image like this," said a repentant J. J. Jackson. "It's almost like a photograph. It measures perfectly to what we know of the *Republic*."

The target wreck lay upright in 1,700 feet of water, about a hundred miles southeast of Savannah, Georgia. In the third week of July, Tapanes e-mailed the image to Stemm and John Morris in Tampa, labeling it "Sailboat #1."

Stemm and Morris knew from the sonar that they had a double-wheeled steamship. Now they had to prove it was the *Republic*. On August 2 the team returned with a small, tethered, remotely operated vehicle (ROV) fitted with manipulator claws and a video camera.

"It could barely hold its position in the Gulf Stream," said Tapanes. "We practically killed the thing." But the camera found a copper-sheathed rudder and the eerie skeletons of upright paddle wheels. The stuff of daily life was strewn across the seafloor—piles of bottles, stacks of shoes, bolts of silk for fancy

Many coins were



Time rots away a wooden barrel and reveals its glimmering contents—silver Seated Liberty half-dollars likely intended to help jump-start the South's economy. Loaded in New York, some of these coins were going home: Many were made in New Orleans, indicated by an O under the eagle. "A coin struck there is scarce and worth upwards of six figures," says Mark Salzberg of Numismatic Guaranty Corporation. "The entire collection is the Rolls-Royce of coins." After six months, Odyssey had recovered more than 51,000 coins—still less than a fourth of the original cargo.

dresses, elegant decanters, dominoes, porcelain dishes, bottled berries to make pies. Later they also found cases of slates, inkwells, and molded glass religious items—candelabras, votive candles—lying stacked like cordwood.

From the heap the claws recovered a brown bottle and a piece of wood. To comply with salvage law, Morris delivered the bottle and wood to a federal court in Tampa to “arrest” the site—to keep anyone else from tampering with it. At a hundred miles offshore, the wreck lay beyond the limits of authority that both the state of Georgia and the federal government had over cultural artifacts, but legal sanction was needed to proceed with recovery. The court granted *Odyssey* exclusive admiralty rights on August 6.

Now convinced that the wreck was the *Republic* and flush with rejuvenated investors, *Odyssey* purchased a newer, larger research vessel, a 250-foot-long former fishing trawler that the company named *Odyssey Explorer*. She would carry a massive new ROV named

Zeus, a 200-horsepower, seven-ton, tank-size robot equipped with powerful manipulator arms that could lift heavy objects as well as small objects gently. The site demanded industrial-strength gear just to get to the target and hold steady. “The Gulf Stream keeps the average Joe away,” said Ernie Tapanes. “It protects the wreck.”

1865

WILLIAM NICHOLS found a shattered economy when his train arrived in New Orleans in November. Reconstruction was in full, painful stride in the city, occupied by Federal troops in 1862. The cargo of the *Republic*, had it arrived on time, would have had immediate impact. Gold and silver coins had nearly vanished from circulation, and people yearned to feel the jingle in their pockets.

Republic was only one of several ships due with hard money for New Orleans that week. As customers read in the *New Orleans Picayune* of October 25, “the *Evening Star*

pressed together in stacks like poker chips.



“There was a ghostliness about it. You could

brought \$376,412, embracing \$100,000 to Mssrs. Brown, Bro. and company, \$84,000 for the Citizens' Bank, \$50,000 to the Canal Bank, a like amount to another party, \$47,456 to Mssrs. Wm. Edwards and company, and \$10,000 to Mr. J. Barker.”

Back in the booming 1840s and '50s, when the city served as the commercial hub of the Mississippi watershed, the city's 13 banks held more than 12 million dollars in gold and silver. The New Orleans mint was one of seven that provided United States currency for nationwide distribution. But, to thwart the impending Union military occupation of 1862, the banks had whisked what hard currency they had left to hidden caches in river valleys, where they could be tapped by a retreating Confederate Army.

Throughout the war much of commerce ran on odd private currencies: scrips, banknotes, or trade tokens issued by department stores, even parish governments. Drinking-house shinplasters and five-cent streetcar tickets served as small change. The joke on the



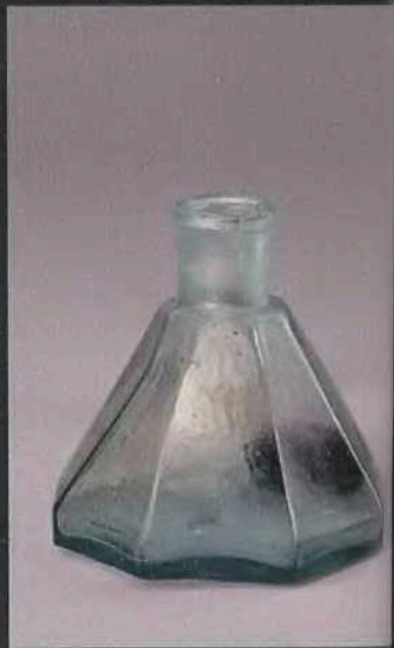
almost feel when the boiler went cold.”

Crucifixes and saintly figures on white ceramic candlesticks spill from wooden crates. “The crew and passengers more than likely prayed for rescue and salvation,” says marine archaeologist Neil Cunningham Dobson. “Isn’t it poignant that these religious goods survived?”





The Republic held a glass menagerie, most of the bottles empty [New Orleans had no glass manufacturers]. Fifty types of bottles have surfaced, many probably destined for cities in the South and frontier West.



Designated by gothic panels and arches, the cathedral bottle [right] was used for pickles, honey, pepper sauce, vegetables, and spices. A mineral-water bottle [above] was made in New York.



Was an ink jar [above] going to one of the new schools for freed slaves? Was a Victorian oil lamp [facing page] a gift for a home? Without the ship's manifest, their destinations remain unknown.



Stored in distinctive bottles [left and right], cure-all medicinal bitters made with roots, bark, and herbs—fortified with about a quarter bottle of alcohol—were consumed nationwide, even by teetotalers.



streets, wrote a citizen, George W. Cable, was that “you could pass the label of an olive oil bottle as money, because it was greasy, smelt bad, and bore an autograph.”

Weeks passed before Nichols received a letter from his family rector in Vermont, George S. Howard, telling him that Thyrsa had died from typhoid fever. She had hung on, he wrote, “in a state of painful suspense” until a telegram confirming her husband’s survival from the wreck had arrived. “The excitement seemed to have kept her up, for when she heard from you, a reaction seemed to take place, and she was seriously ill. . . . She sank gradually under her disease until she peacefully breathed out her life without a struggle or groan.”

In Texas Nichols purchased two cotton plantations and invested in a tannery, but later returned home to wrap up his old life. He married Thyrsa’s sister, Louise, then headed west with his surviving daughter, Lucy. In Illinois he founded a town he named Maywood after his dead, beloved daughter, May. He became a town patriarch, a shrewd businessman, and an inventor of farm implements such as the “Maywood scraper and ditcher” and the screw harrow, a revolutionary soil-cultivating machine.

2003

IN SEPTEMBER, after three intense weeks of welding, refitting, and the installation of computer, survey, video, and archaeological mapping systems, the *Odyssey Explorer* embarked from Baltimore with a mission team of 23, including marine archaeologist Neil Cunningham Dobson, a Scot. Dobson had been under fire from his colleagues in academia. Most archaeologists, as a matter of principle, object to any excavation that results in the sale of artifacts. “The general feeling is that the archaeology will always be compromised if it is commercially driven,” he said. “I feel that this is not fair. At the end of the day I don’t care whether a university or a commercial company pays me to do archaeology. I do the same

standard regardless. I am a professional.” Only a commercial operation, he said, could afford a deep-sea recovery of the *Republic*.

As it roamed across the sunken steamship’s skeleton, the ROV *Zeus* sent back video that played on the monitor screens of the *Odyssey Explorer*, positioned in the sea above. Under the weight of the cargo, the ship’s hull had collapsed like a cooked onion, and from amidships rose the paddle wheels and a 30-foot-tall walking beam, the metal frame that turns the crankshaft of a vertical steam engine. “There was a ghostliness about it,” sonar technician J. J. Jackson said later. “You could almost feel when the boiler went cold.”

Between a ruin of spars, the crew spied something brassy. The video camera zoomed in—the ship’s bell! *Zeus* carefully grasped the



bottom of the cracked, heavy, 14-inch-tall hunk of brass and lifted it to the surface. Corrosion blurred much of the engraved name, but the last four letters were clear—SSEE. The *Republic*, built in 1853, had originally been christened the S.S. *Tennessee*. The bell had never been

changed. Now it was beyond doubt; *Odyssey* had located its prize.

The coins were another matter. The *Republic*’s jumbled remains sprawled over an area nearly the size of a football field and were covered by sand and hardpan coral. Unless the team was lucky, finding the money could take months of salvage work.

On November 5, ROV supervisor Jim Starr was about to go off shift, but they had time for a few more maneuvers. The big ROV had two main tools: a six-inch-diameter Venturi tube, like a giant vacuum cleaner that could either blow sand off or suck it in to clear a site, and a delicate suction cup called a limpet, which could pick up artifacts without scratching them. On the intercom, Starr queried Neil Dobson, who was watching on another monitor: “What do you want to do next?”

“I dunno. What do you want to do?”

“Let’s test the Venturi system,” said Starr. “We just made some repairs to it.”

ROV pilot Gary Peterson deftly maneuvered *Zeus* to a sandy spot near the *Republic's* stern. It wasn't an entirely random choice for a probe; the coins found in the wreck of the gold-rush-era steamer *Central America* in 1991 had been stored in a safe room near the stern. Technician Alan Smith turned on the Venturi tube and began sucking away the sand.

"Stop!" shouted Starr, peering into the monitor screen. "Turn the system off. I see a coin!" The camera zoomed in on the metallic ridge sticking out of the sand. "Nobody said anything," Starr remembered. "We were all stunned. And I finally said to Neil over the intercom, 'You interested in this?'"

Soon five more coins emerged from beneath the billowing sand. The team's hunch, indeed the whole exploration plan, had proved correct. They didn't even have a container ready to bring up the coins, however, so *Zeus* scooted out and looked around the wreck site for something appropriate to use. Thus it was that the first 80 gold coins recovered from S.S. *Republic* were temporarily

Company, which had insured some of the *Republic's* cargo. Odyssey, it appeared, could keep the rest of the money.

Numismatists greeted the collection with awe. A number of individual coins were described as the finest ever found in their categories, and their composite value was estimated at perhaps 75 million dollars.

2004

THYRZA NICHOLS GOODEVE, the great-great-granddaughter of William Nichols, teaches art history at the School of Visual Arts in Manhattan. Joining an Odyssey voyage in February, she brought with her an heirloom gold chain and locket holding a miniature tintype of the first Thyrza Nichols. The photoengraving had held its sharpness over 135 years, and the eyes glinted sternly from a stiff, black New England habit.

She had just recently found letters from her family's past, in a musty old family trunk. "We didn't even know about the shipwreck," she said. "That was never talked about. I think

The S.S. Republic lay buried in the bed of

stored in a white enamel chamber pot.

Within days the Venturi unit revealed a cascade of gold coins, both ten-dollar pieces and twenty-dollar double eagles, spilling from the curved rim of a buried wooden keg. Many were pressed together in stacks like poker chips. On Thursday, November 13, the *Odyssey Explorer* pulled into its home port of Jacksonville with more than 700 gold and silver coins. Waiting was an expert coin assessor, Rob Westfall of National Gold Exchange, Inc., in Tampa.

"These are basically mint-state coins, never circulated," Westfall marveled. "And there's such a diversity of types. To my knowledge there's never been a hoard discovered of Civil War-era coins. This is just amazing."

Odyssey knew there would be other claimants. The U.S. government, for one, had launched an investigation to see if any of the money belonged to a Federal payroll, but that theory proved baseless. And in January 2004 the company paid 1.6 million dollars in compensation to the Atlantic Insurance

it was only a detail of his life."

Indeed, there was more to the man than survival. William Nichols led the 14th Vermont volunteers against Pickett's charge at Gettysburg, he faced down the unquenchable sorrow of losing a wife and child, and he sired a family whose bonds proved wiry tough. The names Thyrza and Lucy alternated through the generations. His daughter Lucy named her daughter Thyrza. "That was my grandmother," said Goodeve. "My mother was Lucy, and here I am, Thyrza."

William Nichols's story was only one among the fortunes of the S.S. *Republic's* 43 surviving passengers. Even now, preserved in the silent flow of the Gulf Stream, the steamship informs us of a time of bold opportunity and national reconciliation, when men could beat their bayonets into plowshares and their swords into screw harrows. □

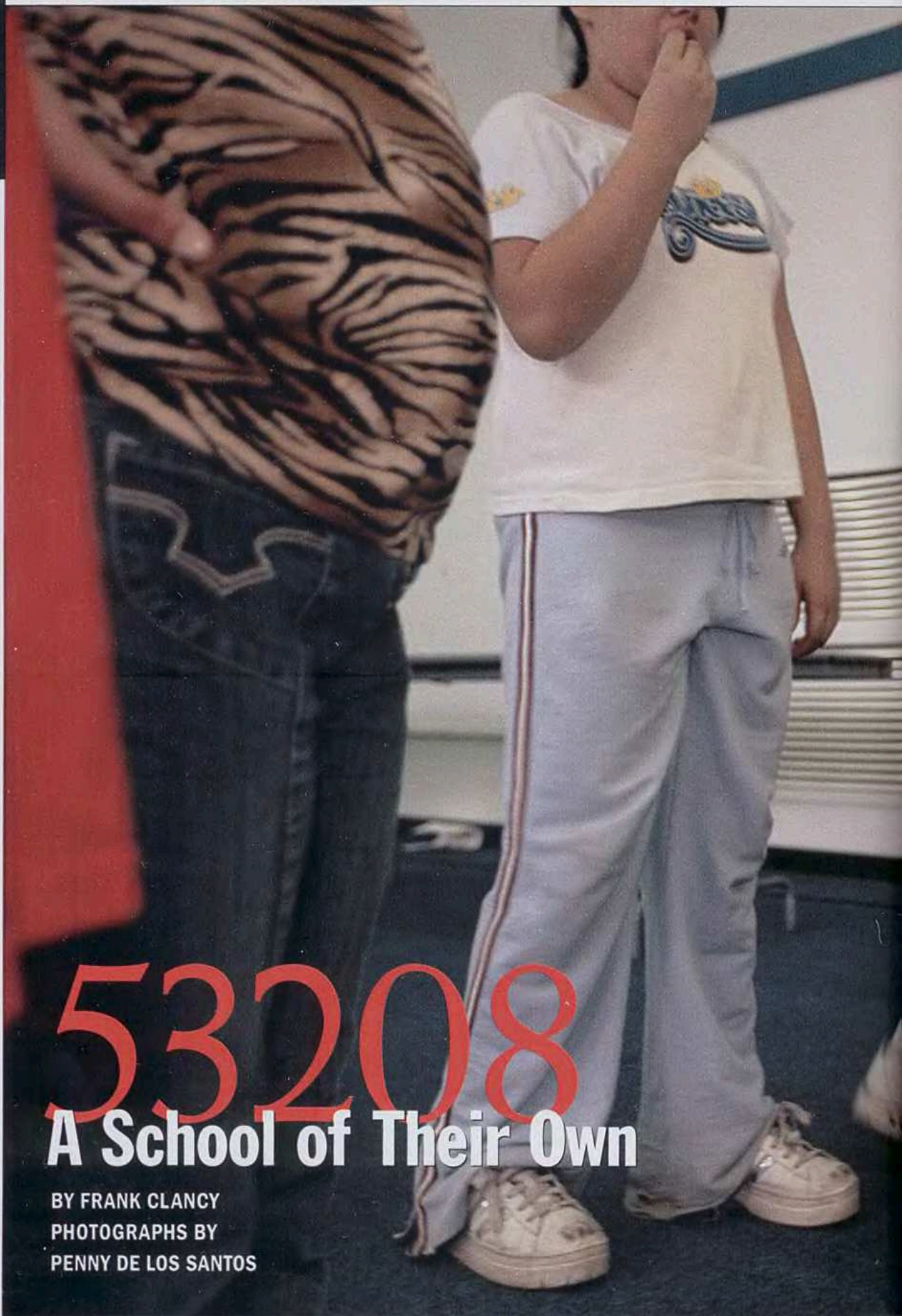
TAKE A VIRTUAL CRUISE of the sunken steamship, zero in on artifacts on the seafloor, and learn how the wreck mosaic was made at nationalgeographic.com/magazine/0409.



Days never end aboard Odyssey Explorer [above] if excavation is under way. Hostage to unpredictable ocean patterns that can thwart ROV dives, crews have to work nonstop when weather permits. Engines also run round the clock to keep the ship's bow pointed into the Gulf Stream so that the powerful current doesn't carry the ship away from the wreck site. Nearly a third of a mile down, the Republic's copper-sheathed rudder [below] will remain as it was found—a sea-shrouded memorial to the year the Civil War ended.

a dark, stygian ocean river.

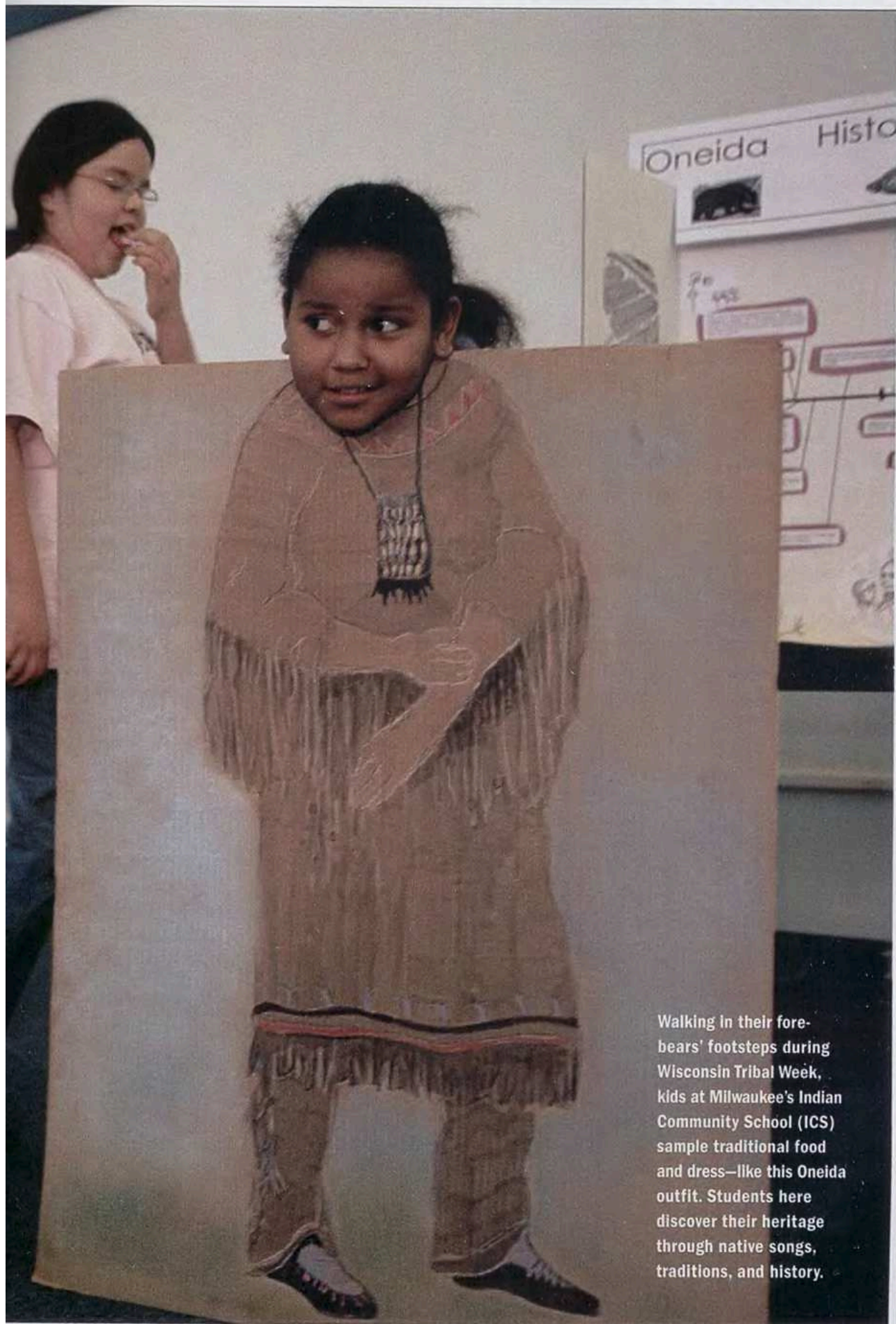




53208

A School of Their Own

BY FRANK CLANCY
PHOTOGRAPHS BY
PENNY DE LOS SANTOS



Walking in their forebears' footsteps during Wisconsin Tribal Week, kids at Milwaukee's Indian Community School (ICS) sample traditional food and dress—like this Oneida outfit. Students here discover their heritage through native songs, traditions, and history.



From the street there's little to distinguish the school in a gritty Milwaukee neighborhood from any of its urban counterparts. What you see is redbrick buildings surrounded by a chain-link fence. Walk through the entrance of the Indian Community School, though, and you immediately note a difference. A mural greets you in Oneida, Ho-Chunk, Ojibwa, Menominee, and Potawatomi. Dream catchers, medicine wheels, drums, jingle dresses, and other artifacts fill hallways and classrooms. Posters recall events in Native American history. Studying Spanish conquistadores, for example, middle school students draw "Wanted" posters detailing their crimes, such as those of Francisco Vázquez de Coronado: "enslaving, killing, and trying to convert to Christianity many of the Native people. Extremely dangerous." But more important differences are less apparent. The school's core values, sometimes called the seven gifts of knowledge—love, respect, wisdom, truth, humility, bravery, and loyalty—echo throughout the K through 8 private school, where children must be descended from a member of an Indian tribe. Most belong to one of Wisconsin's five main tribes, those who speak the languages in the mural.

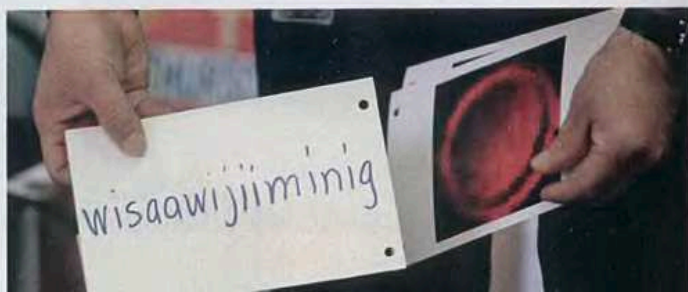
For these students, traditional Indian values are not quaint anachronisms. The school's full-time spiritual leader, Richard Awonohopay—known by his Indian, or "true," name, Waubano, which means "comes from the east"—conducts ceremonies and instructs students and staff. "Our biggest stumbling block is what the larger society teaches about Indians," he says. "A lot of people believe what they see in the movies, that Indians are dead. It is not true. We are a people. We are still alive."

Amy Tromp, who is Oneida, helps keep the culture alive by incorporating tribal rituals in lessons for her fifth-grade class. During a break between reading and math, the sweet smell of burning sage fills her classroom. Wearing a solemn expression, Peter Miller, member of the Stockbridge-Munsee tribe, Bear clan, holds the sage in a shell, carrying it to each of his classmates. They waft the smoke over their faces and bodies, as

Dolls that scream like real babies must be comforted (above) all weekend for a passing grade in a class discouraging teen pregnancy. Learning any of the three native languages taught here can be equally tough. In Ojibwa, "each word is ten miles long," says teacher Larry Beardy, displaying "orange" on homemade flash cards.



53208

POPULATION: 35,000**ICS STUDENTS:** 350**COST TO ATTEND:** Free
(funded by a Potawatomi casino)**TRIBES REPRESENTED:** 14**MONTHLY SWEAT****LODGES:** One scheduled;
more on request

though splashing water from a bowl. Tromp reminds them that this cleansing ritual, known as smudging, is meant to clear the mind.

Native American culture thrives here mainly because of the efforts of three Oneida mothers. Tired of watching their children being mistreated in public schools, they began teaching five children in an apartment living room in 1968. Enrollment grew. Now on the former campus of a Lutheran college, the school is supported by a Potawatomi casino in the heart of Milwaukee.

The casino money has enabled the school to give the children extraordinary services. Families pay no tuition. The school provides free meals and transportation. Classes average 15 students.

Larry Beardy, the school's Ojibwa language teacher, had a far less positive school experience, one that once was not uncommon among Native Americans. He was raised 350 miles north of Thunder Bay in Muskrat Dam, Ontario, where his family survived by hunting, fishing, and trapping. He first saw pavement at 16, when he flew 200 miles south to attend high school in Sioux Lookout. There, Beardy says, he and his friends "were kicked and hit and called all kinds of things, treated like dirt" by whites and the handful of Indians in town. That was 1978. Of the 21 Indian boys who left "the bush" with him, he was the only one to graduate.

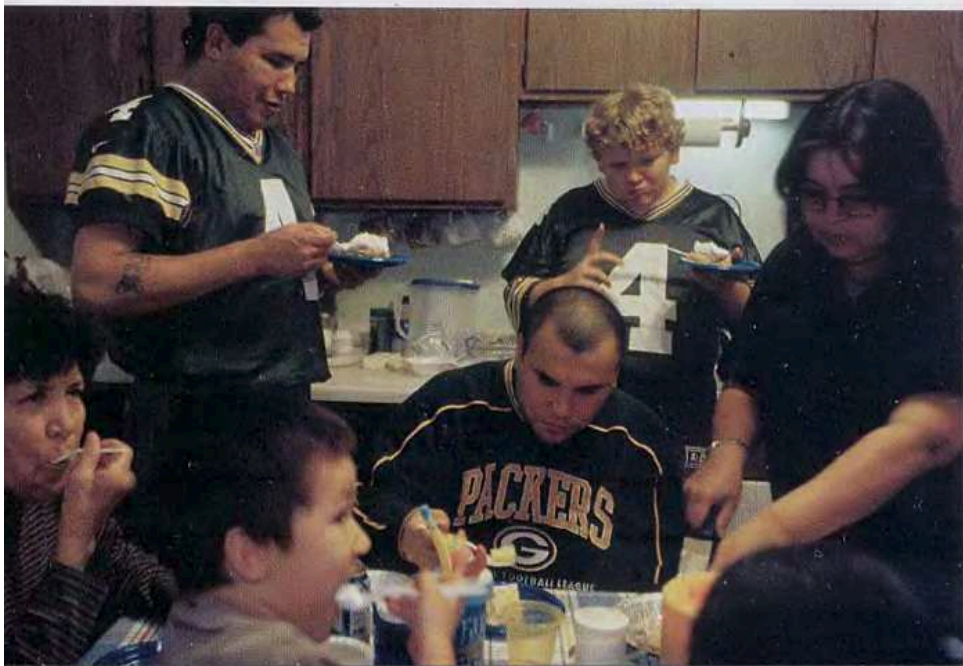
Beardy moves so gracefully in the modern world that it's hard to imagine he experienced such cultural dislocation. His solid grounding in Ojibwa culture and spirituality, he says, gives him strength. "That is what we would like to pass on to the children," he adds. "When they have that, they are able to stand on their own no matter what kind of people they associate with or what environment they are in. They will be able to do whatever they have to do to survive without feeling like they are lost."

Beardy shows off a much loved place of his at school, heading into an abandoned building, upstairs to a room with a wall of soaring leaded glass—the old college chapel. He feels the presence of the past here, he says, of the generations of Christians who worshipped here. For him, the school's sweat lodge is such a place, a way of connecting to the Creator, to the ancestors.



Paintings of cultural touchstones adorn school walls. In the cafeteria Mother Earth watches over students, who get breakfast and lunch provided daily. (This boy brought his own.)

Family gathers at Bunny Tomaw-Connors's home (below) to watch a football game. Her grandsons are the second generation to attend ICS, opened in 1968. "When I was in school, we weren't exactly allowed to talk about being Indian," says Bunny, at left. "Now kids are proud to be in an Indian school. It's brought the whole Native community together."



MILWAUKEE, WISCONSIN

Now some people worry that the school's spiritual foundation is eroding. Casino funding and the school's lease are scheduled to end in 2010. With plans to build a new school, the board of directors laid off more than 40 employees—one-fourth of the staff. Parents bitterly criticized the board. Students petitioned to halt the layoffs. "In the school we are like a family together," one sixth grader said, lamenting the cuts.

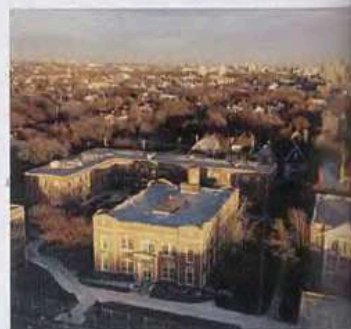
In this extended family, people gather to pray in times of trouble. So one cold March night, Waubano organizes a sweat lodge ceremony for a young man who's slated to lose his job as a teacher's aide. A dozen or so men and boys huddle around a bonfire in the courtyard, seeking refuge from swirling, bitter winds. Buried in the blaze, rocks absorb the energy to heat the lodge, a low hut of canvas and blankets stretched over a frame of maple saplings: the womb of Mother Earth, according to tradition. When the stones ("the grandfathers," Waubano calls them) are ready, everyone crawls into the lodge, around a shallow pit. Waiting in the dim light, the boys joke nervously. One confesses to being afraid. "Face your fear," a friend replies.

The fire tender places seven stones in the pit. Waubano sprinkles tobacco on the rocks, then pours water over them. Steam—the breath of the Creator—envelops everything. The door closes, and Waubano's deep voice, speaking in his native Menominee, rises in the darkness. Sitting shoulder-to-shoulder, the men and boys chant, pray, and drum for hours in the dizzying heat. Three times new rocks are brought in. The participants sweat and sweat, sipping water once, eating a single strawberry apiece.

When the ceremony ends, they crawl out of the lodge, emerging from Mother Earth as they entered the world, cleansed and pure, if only temporarily. Their suffering, Waubano explains later, is a gift to the young teacher's aide, a way of sharing his burden and giving him strength. □



Close to downtown (below), the campus holds sweat lodges (bottom). Smudging (above)—burning sage to purify body and mind—occurs before all school events. Says Joannah Connors, "I get to help give everyone good thoughts."



WEBSITE EXCLUSIVE Find more 53208 images along with field notes and resources at nationalgeographic.com/magazine/0409. Tell us why we should cover **YOUR FAVORITE ZIP CODE** at nationalgeographic.com/magazine/zipcode/0409.



Final Edit



SIGNS FROM EARTH

No High Ground

It's pretty as a postcard from the air. You'd never guess that Male (above), the island capital of the Maldives, is threatened by the serenely blue Indian Ocean. If scientists' worst-case projections come true and sea level rises more than three feet, the Maldives and other low-lying atoll nations could be underwater by century's end.

Male was one of dozens of ports of call for photographer Peter Essick as he made pictures for this month's series of articles about global climate change, visiting every continent but Australia.

In the article's final layout, this image was passed over for a ground-level shot of waves breaking over the seawall (page 18). "This image would have helped convey a sense of place," said picture editor Dennis Dimick. "But space for the article was limited, and this picture doesn't really show what Peter went to the Maldives to show—sea-level rise."

WEBSITE EXCLUSIVE

Cut it or keep it? Find out more about what tipped the balance for this photo and send it as an electronic greeting card in Final Edit at nationalgeographic.com/magazine/0409.

ON ASSI

ON THE ROAD, IN THE FIELD

STEAMSHIP REPUBLIC

When All the Pieces Come Together

High-tech teamwork exposes shipwreck



He used one little digital camera to shoot the images for this photomosaic of the sunken *Republic* shipwreck (below, with detail at right), but photographer **Jonathan Blair** (above) was part of a big team. Each time the remotely operated vehicle carrying the camera went to work, so too did a manager, a navigator, three ROV operators, two pilots, and a data compiler.

The team's photos were made as the ROV plied a grid pattern some three feet above the wreck. Since at that level the camera captures just a few feet at a time, hundreds of images compose the mosaic of the ship and its debris field (see pages 111-13). These were "stitched" together with graphics software by onboard computer guru Gerhard Siefert. The process is easier than it was in the past, says Jonathan. Back then, for mosaics, "We had to get down on the floor for cutting and pasting."

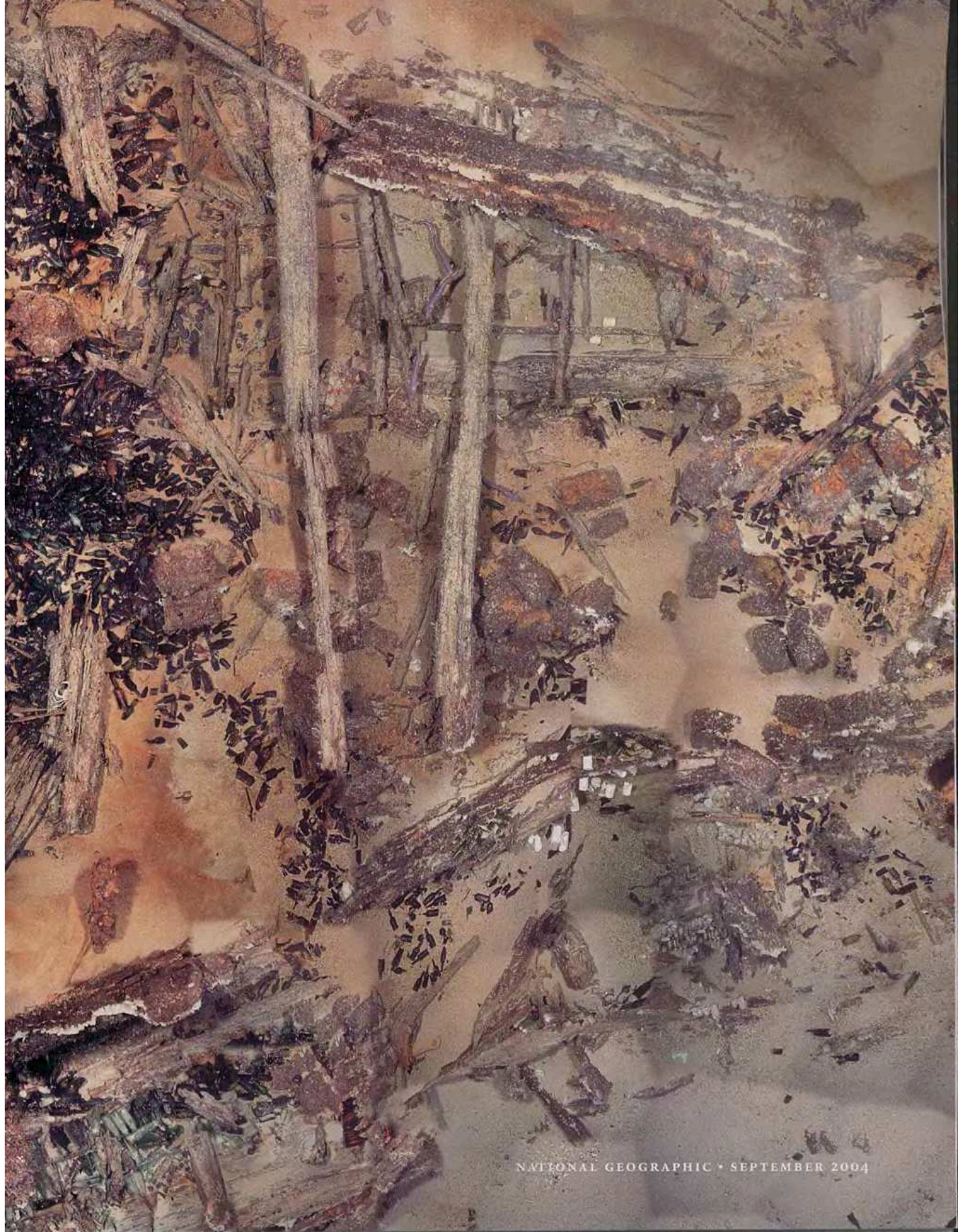


AREA ENLARGED AT RIGHT



GOVERNMENT

COVERING THE WORLD





CHRIS HOLM (ABOVE); PETER ESSICK

INDIAN RENAISSANCE

Stirring Things Up in Minnesota

“Once in a while, it’s nice to participate and experience the culture you’re observing,” says photographer **Maggie Steber**, at right.

On the Bois Forte Chippewa reservation in northern Minnesota, Maggie photographed tribe members harvesting wild rice on Nett Lake by knocking the grains

off into their canoes with wooden sticks. She then joined a traditional “parching party” at the Zika family home. Tossing the rice, or *manoomin*—a staple of both their diet and culture—in a heated trough prepares it for storage, says Maggie, who is herself one-quarter Cherokee.

WORLDWIDE

Adélie penguins weren’t the only strange birds writer **Fen Montaigne** (below, in black, with biologist Bill Fraser) observed during a month in Antarctica. Palmer Station’s human residents function as “a true family”—which means, as in many families, some odd traditions. When a supply ship pulls out of the harbor, for instance, folks at Palmer see it off by plunging

into the ocean themselves. This love of the cold must be catching. Fen admits, “I tried it twice.”

Virginia Morell also spent time being cold during work on her climate change article; she reported from a refrigerated lab designed to safeguard glacial core samples. But real chills came when Columbia University scientists toured Manhattan with her and explained how climate change may affect the city. If the Atlantic starts to warm, they said, hurricanes might not dissipate before they reach New York, as they usually do now. “Storm surges could swamp lower Manhattan,” Ginny says. The water level of the Hudson at the Battery’s gauge station has already risen, she learned, “about

a foot over the last century,” and the trend is expected to continue.

Writer **Daniel Glick** asked a local Alaskan whether the grizzly repellent he’d used earlier in his reporting would be useful against polar bears. Sure, he was told: Just spray yourself in the face so you can’t see while you’re being eaten. Daniel has long been acquainted with where the wild things are: *Monkey Dancing*, his book about taking his two young children on a trek around the world, is just out in paperback from PublicAffairs publishers.



WEBSITE EXCLUSIVE Find more stories from our authors and photographers, including their best, worst, and quirkiest experiences, at nationalgeographic.com/magazine/0409.

Notice of Expanded and Modified Settlement for Current or Former Owners of Property in which Entran II Hose was or is used for Radiant Heating or Snowmelting The Settlement now includes all 50 States and Canada.

In October 2003, a class action settlement was reached between certain Entran II property owners and The Goodyear Tire & Rubber Company and Goodyear Canada Inc. ("Defendant"). This proposed class action settlement included 44 of the United States and Canada. You may have received a notice of this Original Proposed Settlement.

After further negotiations, representatives of Entran II property owners in six additional states agreed to join in the proposed class action settlement in June 2004. As a result, the Settlement was amended and the Settlement Class now includes present or former Entran II property owners in all 50 United States and its territories and possessions, and in Canada. Changes have also been made to the Original Settlement Agreement to make more Entran II property owners eligible for a payment.

What is the Litigation About?

Plaintiffs allege that Defendant manufactured defective Entran II hose. The product was used in radiant heating and snow melting systems. They claim the hose is prone to leaking when operated under normal conditions. Entran II was also known as *Twintran*, *Nytrace*, *Entran II Trace*, *Entran II Wire*, *Entran 2*, *Entran 2 Trace*, and *Entran 2 Wire*. Defendant denies all claims of wrongdoing made by Plaintiffs. Defendant believes that if properly maintained, Entran II hoses do not cause a problem.

Who is Involved?

You may be a member of the Settlement Class if you are the current or former owner of property in which the Entran II hose has been installed. The property must be in the United States, its territories and possessions or Canada. To see if your hose is covered by this Settlement, you should check the Settlement Website or call the toll free number below.

What are the Settlement Terms?

The Settlement Fund will be \$300 million. Payments into this Fund will be made over a five-year period. Depending upon the number of claims and other factors, Class Counsel estimate, but can not guarantee, that some Class Members may receive 50% or more of the cost of remediation after payment of attorneys' fees and costs. Information on the specific relief Class Members can expect is detailed in a document called the Amended Plan of Distribution and Allocation. Class Counsel developed the Plan with the assistance of the Special Master appointed by the Court and other interested parties. The Plan is available on the Settlement Website or by calling the number below.

The attorneys will petition the Court for attorneys' fees of 30% of the Settlement Fund, plus reasonable expenses and costs payable from the Settlement Fund. The Motion for attorneys' fees, expenses and costs shall be submitted to the Court no later than August 5, 2004.

What Are My Legal Rights?

• **If you wish to remain a member of the Settlement Class**, and you did not request to be excluded from the Original Settlement, you do not have to do anything. But, to share in the Settlement

Fund you must file a claim as discussed below. If the Court approves the proposed Amended Settlement, you will receive the benefits of the proposed Amended Settlement. You will also be bound by all the Court's orders. This means you will drop any claims you may have against the Defendant that are covered by the Settlement.

• **If you requested to be excluded from the Original Settlement**, you still have the opportunity to participate in the Amended Settlement. You may join the Amended Settlement by submitting a Request to Re-Join to the Claims Administrator in writing by **September 10, 2004**. Requests to Re-Join are available by calling the toll-free number below or visiting the Settlement Website.

• **If you wish to file a claim**, you must complete a Claim Form. You do not have to send in a Claim Form if you already did so under the Original Settlement. You can get a Claim Form by contacting the Claims Administrator in writing, at the address given below, or by calling the toll-free number. It is also available on the Settlement Website. Claim Forms must be signed and postmarked no later than **October 19, 2009**.

• **If you do not wish to be a member of the Settlement Class**, you must submit a Request for Exclusion to the Claims Administrator by **September 10, 2004**, as described in the Long Form Notice. If you submitted a proper and timely Request for Exclusion from the Original Settlement, you do not need to submit an additional Request for Exclusion in order to remain excluded from the Settlement Class.

• **If you wish to object to the Amended Settlement**, you must submit your objections in writing to the Court, Lead Class Counsel and Defendant's Counsel by **September 10, 2004**, in the form described in the Long Form Notice.

When Will the Settlement be Approved?

The United States District Court for the District of New Jersey will hold a Fairness Hearing to decide if the proposed Amended Settlement is fair, reasonable and adequate on **October 19, 2004**. The Court will hold a separate second Hearing to consider Class Counsel's request for attorneys' fees, expenses and costs on **November 8, 2004**. Both Hearings will be held at 10:00 a.m. at the United States District Court for the District of New Jersey, 402 East State Street, Room 2020, Trenton, N.J. 08608.

In addition, the Ontario Superior Court will also hold a Fairness Hearing to decide if the proposed Amended Settlement is fair, reasonable and adequate. That date is posted in the Canadian Notices and at www.entraniiisettlement.com.

If you remain a member of the Settlement Class, you or your counsel have the right to appear at your own expense before the Court and object to the proposed Amended Settlement. However, in order to object, you must file a written objection, as outlined in the Amended Settlement Agreement and Long Form Notice. Objections must be filed by **September 10, 2004**.

Entran II is an orange rubber hose used in radiant hydronic heating and snowmelt systems, usually stamped with the name "Heatway" or "Heatway Systems" on the outside.

For Information on the Proposed Amended Settlement, Your Rights and a Copy of the Long Form Notice and Claim Form:

Visit: www.entraniiisettlement.com Call: 1-800-254-9222

or Write: Entran II Claims Administrator, P.O. Box 24, Minneapolis, Minnesota 55440-0024

PLEASE DO NOT CALL THE COURT.

Flashback



INDIAN RENAISSANCE

A Gifted Past

During the Society's early days, unsolicited photos occasionally found their way into our archives. In 1917 an 86-year-old retired New York dentist sent the GEOGRAPHIC some pictures—including this portrait of an Apache man—made “in Arizona away back in 1879 & 80. There are some good ones you could use if you should ever write up and illustrate Arizona,” the dentist, T. S. Hitchcock, wrote. “Now, you can keep them. If they're worth a year's subscription, all right.” They remained unpublished, until recently. And as far as we can tell, Hitchcock never did get free magazines.

—Margaret G. Zackowitz

WEBSITE EXCLUSIVE

You can access the Flashback photo archives and send electronic greeting cards at nationalgeographic.com/magazine/0409.